REFLECTIVE INSTRUCTIONAL STRATEGIES, STUDENTS' CONCEPTUAL CHANGE AND ACHIEVEMENT IN BIOLOGY IN SECONDARY SCHOOLS IN ABEOKUTA, OGUN STATE, NIGERIA

BY

Olubukola AbidemiOke
Matriculation Number: 142246
NCE (Biology/ Chemistry)
B.Sc. Ed HONS. Integrated Science (Biology)(Ilorin)
M.Ed.Science Education (IBADAN)

A Ph.D Thesis in the Department of Science and Technology Education,
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CERTIFICATION

I confirm that this research was done by Olubukola Abidemi Oke in the Department of Science and Technology Education, Faculty of Education, University of Ibadan, Ibadan, Nigeria.

.... 30/03/2021

SUPERVISOR

PROFESSOR TEMISAN ANGELA IGE

Ph.D., M. Ed. (Ibadan) B. Ed. (Benin)

Science Education

Head of Department,

Science and Technology Education, Faculty of Education,

University of Ibadan, Ibadan, Nigeria.

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DEDICATION

This Thesis is dedicated to my late mother

CHRISTIANAH OMOYENI ADUNNI SOTUNDE

and my late husband

AKEEM AKOREDE ADEKUNLE OKE

May their gentle souls continue to rest in peace and remain on the bosom of the Lord eternally.

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ABSTRACT

Students often memorise complex biological concepts without really understanding them. This has contributed to massive failure in the subject matter. Reports also revealed that the lack of understanding stems from teachers' use of inappropriate instructional methods. Previous studies adopted instructional strategies which enable students to learnbiologywithoutreflectingontheirpriorknowledge.Therefore, this study determined the effects of reflective inquiry and explicit reflective instructional strategies on students' conceptual change and achievement in biology among secondary school students in Abeokuta, Ogun state,Nigeria. The moderating effects of prior knowledge and mental ability were also examined.

Kolb's theory of Experiential Learning provided the framework, while the pretest posttest delayed control group quasi-experimental design with a 3x3x2 factorial matrix wasadopted.The study employed a multi-stage sampling technique. Two Local Government Areas (LGAs) in Abeokuta were randomly selected (Abeokuta North and Abeokuta South). Three secondary schools were randomly selected from each LGA an d one intact class of Senior Secondary II biology students from each school were enlisted making a total of 280 participants (150 male, 130 female). Instruments used were Students' Biology Concept Achievement Test (r=0.86), Students' Mental Ability Test (r=0.85), Students' Biology Conceptual Change Assessment Scale (r=0.79), Students' Students' Background Knowledge Probes of Biology Concepts(r=0.89) and instructional guides, while treatment lasted 10 weeks. Data were analysed using descriptive statistics and Analysis of Covariance at 0.05 level of significance.

Treatment had significant main effect on students' conceptual change in biology ($F_{(2,241)}$ =21.84; partial $\eta^2 = 0.15$). Reflective Inquiry Strategy had the highest conceptual change mean score (15.79) followed by Explicit Reflective Strategy (15.40) and Conventional Strategy (12.79) groups. Treatment had significant main effect on students'achievement in biology ($F_{(2,241)} = 55.53$; partial $\eta^2 = 0.32$]. Participants in ERS group had the highest achievement mean score in biology (24.64), followed by IRS (18.73) and CS (13.36) groups. Prior knowledge had a significant main effect on achievement in biology [$F_{(1,241)} = 7.80$; partial $\eta^2 = 0.03$]. Students in experimental groups with valid prior knowledge had higher achievement mean score (19.70), while those in control group with invalid prior knowledge had lesser mean score (17.57). Prior knowledge and mental ability had no significant main effect on students' conceptual change and achievement in biology. There was no significant interaction effect of treatment, prior knowledge and mental ability on students' conceptual change and achievement in biology.

Reflective inquiry and explicit-reflective instructional strategies improvedstudents' conceptual change and students'achievement in biology in secondary schools in Abeokuta, Ogun State. Teachers should adopt these strategies to facilitate conceptual understanding and improve students'achievement in biology.

Keywords: Reflective instructional strategy, Students' prior knowledge,Mental

ability, Conceptual change, Achievement in biology
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CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

Knowledge of Biology gives a range of balanced learning encounters through which learners builds up the essential logical learning and comprehension, get aptitudes and procedures, constructive qualities, and frames of mind for self-awareness and for contributing towards a technological and scientific world (Prerna, 2016). Through the learning of Biology, learners obtain significant procedural and theoretical information to enable them to comprehend a considerable amount of the contemporary issues, and become mindful of the interconnections between science, innovation and society. It has been recognized as one of the subjects which produce knowledge that enables man to provide solutions to most global social problems (Ibe and Meduabum, 2011).

The study of Biology in secondary schools and higher institutions of learning furnishes learners with a comprehension ofnot only the structural and functional composition of man and other living organisms in general, but also the relationship of these organisms with their immediate environment. Biology also enables students to acquire the knowledge required for the attainment of diverse human and societal needs in order to improve living standards. Therefore, knowledge of Biology and its application is relevant in all spheres of life. Biology entails the study of various disciplines such as Botany, Zoology, Biochemistry, Plant and Animal Physiology and Anatomy, and Genetics(Prerna, 2016).

The complex nature ofBiology makes most studentsdisposedto rote learning whereby they memorise numerous unrelated facts.This phenomenon has been noted to contribute to misconceptions in the subject matter (Coley, 2015). Learners find it difficult to understand many biological concepts due to the use of conventional strategy on the part of the teachers (Abimbola, 2015). According to the West African Examinations Council Syllabus (WAEC, 2015) and the National Examinations Council Syllabus (NECO, 2016), acquisition of biological knowledge enables the learners to apply biological principles to everyday life in matters that are personal, environmental, economic, and connected to community health. Therefore, Biology, being one of the science subjects offered in secondary school in Nigeria, is expected to be effectively taught by well trained and qualified teachers who are versatile in the use of diverse instructional strategies to teach the subject in a way that learnerswould have conceptual understanding of the subject. Kareem (2014) and Ige and Kareem (2012) posited that in order to make the study of Biology exciting and relevant, it is important that teachers adopt different instructional strategies, which enable learners to learn Biology by reflecting on what they had already known before they enter the classroom. This would help the learners to gain new experience through inquiry. The use of reflective instructional strategies helps to animate premium and make inspiration for learning among learners with a scope of capacities and yearnings. Furthermore, reflective instructional strategies assist learners to build up the capacities to make logical request, think deductively, fundamentally and innovatively; and tackle issues exclusively and cooperatively in Biology (Ogunbameru and Raymond, 2012).

In spite of the importance of teaching and learning of Biology, studies have revealed that most learners have poor conceptual understanding of biological concepts thereby causing the learners to perform poorly in the subject matter. The poor performances had been attributed to the use of ineffective instructional strategies to teach learners (Kareem, 2014; Burgoon, Heddle and Duran, 2010). Most teachers still teach their learners using the conventional instructional strategy. This makeslearners unable to link what they had already known before they enter the classroom to the new knowledge to be gained after instruction (Coley, 2015). Teachers, therefore, need to find out the learners’ entry knowledge. Learners’ prior knowledge is what learners had already known before having an encounter with new knowledge or learning experience (Abimbola, 2015; Burgoon, Heddle and Duran, 2010). A concept could mean an image of a thing held in the mind or an abstract notion of a thing. Concepts are mental representations that can be expressed by a simple word or sets of ideas described through words. The erroneous and naive understanding of concepts is generally referred to as misconceptions. According to Coley (2015), a misconception is not just a factual error, but a belief, which is contrary to how scientists understand a matter; it is a phenomenon that arises from a learner’s intuitive way of organising knowledge. Misconceptions are those intuitive and erroneous pre-existing ideas that learners bring to the classroom before their exposure to new knowledge. Misconceptions can really impede learning because learners being unaware that the knowledge, they hadcan wrongly interpret new experiences based on the erroneous understandings.

Consequently, they areunable to achieve understanding of the new information being shared (Ige and Kareem, 2012).

Previous findings revealed that learnersof biological sciences at all different levels of education had confusion about concepts of 'respiration' and 'photosynthesis' despite the fact that they were taught directly from the grade school level (Abimbola, 2015; Coley, 2015; Burgon, Heddle and Duran, 2010). Learners experienced troubles in grasping the ideas of respiration and 'photosynthesis, they confused one with the other and they attempted to comprehend the connection amongst respiration and imperative organic capacities such a circulation of blood in man. Furthermore, learners had misconception as respects the energy source; they comprehended that photosynthesis is a mechanism where the energy required forever comes straightforwardly from the sun. Misconception in Biology could be as a result of poor communication skill of the Biology teacher during classroom instruction. This communication problem constitutes misunderstanding on the part of the leaners. However, it has been observed that communication could be a problem for learners' learning, especially when teachers fail to provide challenging learning environment through their choice of words (0lagunju, 2005). Poor communication by some Biology teachers could also lead to ineffective questioning style (Ibe and Meduabum, 2011). This results in a neglect of questions which involve higher order thinking skills. The Biology teachers were observed to frequently ask low level cognitive questions which required learners to recall information easily from what was taught as opposed carrying out high cognitive tasks which would compel them to be critical and creative why responding to the questions. Kareem (2014) also attributed learners' misconceptions of biological concepts to the inability of teachers to practice all the necessary classroom pedagogical skills such as use of instructional strategies and classroom management acquired during teacher training. Teachers need to continuously use these classroom pedagogical skills for effective teaching and learning of Biology. So as to accomplish important and lasting learning. Misconceptions should be remediated using reflective instructional strategies which could bringa conceptual change in learners after some time. One of the goals for science education is to have leaners learn ideas definitively and to utilize ideas in their everyday life (NERDC, 2013; Yuruk and Cakir, 2000). Providing the right and relevant experiences in the classroom, through interaction with a rich learning environment, could help individual learner have a gradual shift from misconceptions of scientific concepts to correct conceptual understanding, and enable them to transfer the knowledge gained into life experiences (Ige and Kareem, 2012). This gradual shift from existing misconception or intuitive way of thinking into correct conceptual understanding of scientific concepts is referred to as conceptual change (Abimbola, 2015; Chi and Roscoe, 2002).

Various strategies have been employed in order to identify the patterns of conceptual organization that learners possess for various related concepts as established in their cognitive structures. Similarly, prior knowledge have been linkedwith new information and the degree to which they comprehend the occasions in the characteristic life by partnering them with their new information (Kurt, 2013). Some of these strategies include reflective strategies (Kareem, 2014), drawings (Cetin, 2013), simplex and cognitive coaching strategies (Arowolo, 2012), interviews (Kose, Ayas and Usak, 2008), concept maps (Novak, 2012) analogy (Bahar, 2008), two-tier multiple-choice tests (Tekkaya, 2003) and many more. Several tools had been used by previous researchers to examine learners' conceptual change among which are Diffusion and Osmotic Diagnostic Test (Odom and Barrow, 2002), and Conceptual Change Assessment Test (Villafane, Barley, Loertscher, Minderhout, Lewis, 2010). The afore-mentioned strategies and tools have one way or the other contributed to learners' conceptual understanding in Biology.It also avails Biology teachers the fore-knowledge of the fact that learners come to classroom with their intuitive prior knowledge of Biology concepts which could be valid (correct) or invalid (incorrect) compared to the scientific meaning (Abimbola, 2015; Kurt, 2013). These strategies do not provide learners with relevant classroom experience, though the interaction with a rich learning environment could help learners have a gradual shift from misconception. It is the 180researcher's opinion that learners' prior knowledge of Biology concepts should be thoroughly identified by the teacher before exposing the learners to new instructional experience.

It has been noted that most Biology teachers still prefer to use conventional method to teach biological concepts (Yahaya, 2012).

David Kolb (1976) built up a theory of experiential learning that can give a helpful model of meaningful learning in science. This is called the Kolb's Experiential Learning Cycle. The cycle contains four unique phases of learning which are *concrete experience, reflective observation, abstract conceptualizing* and *concrete experimentation*. The learning cycle prescribes that it is not sufficient to have inclusion to learn. It is moreover imperative to consider the experience to make theories and figure thoughts which would then have the option to be associated with new conditions (Kolb, 1976). The researcher, therefore, holds the opinion that the use of instructional strategies, which do not support learners' conceptual change, could lead to under-achievement in Biology among secondary school learners.

Recent West African Examination Council reports (WAEC, 2011-2017) have shown under- achievement of learners in Biology to be one of the educational challenges in Nigerian secondary schools.The West African Examination Council Examiners' report on the performance of learners in the Senior Secondary School Certificate Examination in Ogun State indicates that a relatively high rate of failure in Biology is being recorded among learners in the Senior School Certificate Examination (SSCE) on yearly basis in the State. This report reveals low achievement in Biology at the senior school certificate examination, and leaves one in doubt about the effectiveness of the instructional strategies commonly used by Biology teachers for the teaching and learning of Biology. Also, in some of the previous studies on conceptual change and achievement in Biology, teacher's use of conventional strategy in the classroom had been considered as a contributing factor to under-achievement in the subject (Abimbola 2015; Ozmen and Demigrough, 2013; Ige and Kareem, 2012). The conventional strategy is the teacher-centered instructional scheme that could make learners to be passive to classroom instruction, which may also affect their mastery of biological concepts. Biology cannot be effectively learnt without interaction between the teacher, learners and the instructional strategies that can bring about conceptual change. Therefore, adequate attention should be paid to the use of effective instructional strategy for learners which could bring about positive conceptual change in Biology.

The West African Examination Council chief examiners' reports (WAEC, 2015) revealed that performance of candidates in Biology fell below expectation. The examiners' report discussed the candidates' weaknesses as poor spelling, poor observation and misconception of biological terms, and poor deductive reasoning and misinterpretation of questions. Mamalanga and Awelani (2014) concluded in their study that one of the possible factors responsible for poor performance in Biology among secondary school learners is poor methods of teaching and of assessing the subject matter. In support of these views, analysis of learners' achievement in May/June Senior Secondary Certificate Examinations in Biology in Ogun state from

2002-2017 as shown in Table 1 presents a relatively poor performance of candidates that sat for the examination each year.

Table 1: Table of Learners'Achievement in Biology in May/June SSCE in Ogun State from 2002 – 2017

Year	Total entry **No of candidates**	Total No of candidates **Examined**	Credit passes 1 – 6 **No of candidates**	% of Candidates **With credit passes 1-6**	% of candidates **Failed**
2002	34449	24503	17725	27.66	72.34
2003	27968	26253	10896	44.15	55.85
2004	28554	27932	17041	38.99	61.01
2005	30005	29795	10440	35.04	64.96
2006	32515	32001	15552	48.60	51.40
2007	35282	34393	11478	33.37	66.63
2008	35914	34999	11879	33.94	66.06
2009	38127	37228	12609	33.87	66.13
2010	36983	36123	11879	33.90	66.10
2011	42782	41811	16095	38.50	61.50
2012	47108	46451	15254	38.82	61.18
2013	48786	45743	23633	51.66	48.34
2014	48505	41725	14221	29.34	70.66
2015	42320	35167	10323	29.35	70.65
2016	38936	32780	8355	25.49	74.51
2017	29625	25110	9532	37.96	62.04

Source: Statistics Section, West African Examination Council (WAEC) State Office, Abeokuta, Ogun State

Table 1 shows that percentage of passes at credit level each year decreases, except in 2006 and 2013 where the percentage of candidates who passed WAEC in Abeokuta, Ogun State is almost equal to percentage of candidates that failed. Generally, the performances of candidates in Biology have been dwindling over the years as seen in Table 1. The poor performance of learners in the subject has been attributed to poor understanding of concepts like osmosis and diffusion, cellular respiration, photosynthesis, ecology, genetics, inheritance and evolution (Abimbola, 2015; Coley, 2015). WAEC Chief Examiners' report (2016) also noted that most teachers may not have covered the teaching of those concepts and this may result in poor understanding, subsequently causing under-achievement in the subject matter.

Studies have likewise uncovered that the achievement of learners in Ordinary Level Biology was reliably poor throughout the years because of the absence of applied comprehension of fundamental natural ideas (Abimbola, 2015; Coley, 2015). This has been a noteworthy wellspring of worry to the school executives, guardians and the administration largely. Several studies had been conducted in the past on conceptual change and achievement in Biology which recorded many Biology concepts which seem difficult for learners to understand.Some of these concepts are osmosis and diffusion, cellular respiration, photosynthesis, evolution, genetics, inheritance and variation and many more (Abimbola, 2015; Coley, 2015). The selected Biology concepts used for this study are osmosis and diffusion, photosynthesis, and cellular respiration. These concepts have been identified by chief examiners to constitute major parts of the Senior School Certificate Examinations conducted for learners yearly by West African Examination Council and National Examination Council (WAEC and NECO chief examiners' report, 2017). In order that Biology teachers teach effectively, there is need for the teachers to engagelearners in inquiry-based activitiesthrough the use of reflective instructional strategies, which may trigger learners' reflection on their prior knowledge of biological concepts. In support of this view, Kareem (2014) and Ige and Kareem (2012) suggested that teachers need to teach the learners and guide them to reflect on what they know before they enter classroom and on what they do in classroom, how and why they do it, in order to bring about conceptual change in the learners through the use of reflective instructional strategies.

Reflective instructional strategies could be described as teaching and learning strategies which stimulate learners to utilize encounters to find learning themselves through reflection on past encounters. Their disclosures may prompt securing logical abilities and a great frame of mind. Learners find how to take care of logical issues and answer inquiries all alone, make inferences, and to assume ability for their very own learning. These procedures mirror a way of thinking of training that perspective the learner as a wellspring of learning as opposed to a clear slate whereupon the instructor records data (National Policy on Education, 2013). Reflective instructional strategies lead learners beyond basic skills to higher levels of thinking and complex reasoning which could result in conceptual understanding and bring about a gradual shift from misconception (Kareem, 2014; Ige and Kareem, 2012).

Many studies have been carried out on reflective instructional strategies using pre-service teachers. These studies have concentrated on strategies using journal writing and diary keeping, story sharing or telling self-report, learners' feedback, lesson recording and mentoring (Owino, Osman and Yungungu, 2014; Ogonor and Badmus, 2010; Ogonor and Badmus, 2006). There have not been enough scholarly efforts to establish the extent to which other strategies such as reflective inquiry and explicit-reflective strategies influenced secondary school learners' conceptual change and achievement in Biology in particular (Abd-El-Khalik, 2001). This study, therefore, focused on the use of reflective inquiry strategy and explicit-reflective strategy.

Reflective Inquiry Strategy could be identified as an instructional approach that invigorates learners to utilize encounters to find learning and solve problems on their own leading to acquisition of new knowledge, understanding, skills and attitude. Ige and Kareem (2012) asserted that reflective inquiry instructional strategy, when used in classroom instructions by science teachers, provide extensive preparation for learners' interaction with the teacher as well as promote inductive and critical thinking and problem-solving among learners. Therefore, reflective inquiry instructional strategy could be used as a tool for facilitating conceptual change in Biology (Chi and Roscoe, 2008).Freiberg and Driscoll (2005)suggested six steps that learners may follow as the teacher teaches with inquiry. The steps include forming and refining a question the learners wish to answer; collecting instances and observing facts likely to be related to as possible answers; putting facts or instances into a class or classes, and making generalizations about them; making intelligent guesses (hypotheses) based on the facts to suggest possible explanations; testing to see which hypothesis, if any, is the correct one; and using the new information as a basis for further reasoning. From findings of existing studies on the conduct of reflective strategies in science, use of explicit-(NOS) and provide leaners with learning outcomes that are more encouraging. reflective instructional schemewere found to enhance learners' knowledge of nature of science. The explicit-reflective scheme uses instructional practices such as focusing on critical content, sequencing skills logically, reviewing prior skills and knowledge before beginning instruction, and providing guided and supported practice to enhance reasoning skills (Archer & Hughes, 2011). Adoption of this scheme leads to conceptual change wherein leaners develop a more sophisticated NOS disposition.Abd-El-Khalik (2001) used explicit-reflective activity-based instructional strategies to promote teachers' nature of science views. Generally, few explicit-reflective activities have been undertaken for younger leaners, especially in secondary schools, to improve their academic accomplishment in Biology. However, not much success had been recorded,while less attention had been paid to the use of reflective inquiry and explicit-reflective instructional strategies to bring about a conceptual shift from misconceptions to correct conceptual understanding of Biology on the part of theleaners. Different variables have been identified in previous studies as extraneous variables which influence learners'conceptual change and accomplishment in Biology. Some of these factors are gender, verbal capability, mental capability, communication style, and prior knowledge (Eberly, 2015). Similarly, Abimbola (2015) found that learners' faulty prior knowledge of biological concepts, which they had already had from home, had attributed to misconception of the subject matter. Prior knowledge of leaners was measured for all of them before their exposure to intervention in the course of this study.Past studies also identified general and specific mental abilities such as verbal reasoning, mathematical reasoning, spatial reasoning and logical reasoning and it was noted that people with high level of general abilities "g" tend to be more successful in life and achieve higher in academic tasks (Douglas, 2007, Bamidele, 2000).Therefore, learners' mental capability and prior knowledge were used in this study as moderator variables.

Earlier learning is characterized as a multidimensional and various levelled element that is dynamic in nature and comprised of various kinds of information and abilities (Smith, 2007). Earlier information has for quite some time been viewed as the most significant factor impacting learning and learner accomplishment (Abimbola, 2015). The sum and nature of earlier information obtained emphatically impact both information procurement and the capability to apply higher-request subjective critical thinking aptitudes in leaners (Eberly, 2015). At the point when educators have a clearer impression of the learners' earlier information level, regardless of whether legitimate or invalid, it encourages them to adjust their instructing to the necessities of the student (Smith, 2007). All the more in this way, attempting to get the hang of something without having satisfactory earlier information or having misinterpretations may bring about repetition remembrance, which is a pointer that the learners can't relate the new learning to their current learning (Abimbola, 2015; Eberly, 2015). A few devices have been utilized in past examinations to survey learners' earlier information of biological concepts. Some of these tools are performance-based prior knowledge assessment (Odom and Barrow, 1995), background knowledge probe(Eberly, 2015), and prior knowledge self-assessment (Smith, 2007).

In spite of previous use of all the afore-mentioned tools to measure learners' prior knowledge in order to remediate their misconception in Biology, examiners' reports on yearly basis reveal misconceptions of Biology concepts among leaners in secondary schools in external examinations (WAEC and NECO, 2012-2017). In this study, Background Knowledge Probes was used as a tool to measure learners' prior knowledge of the selected concepts (Eberly, 2015). Basically, Background Knowledge Probes (BKP) was adapted from Angelo (1991) by the researcher to gather explicit and valuable input on learners'prior knowledge in this study. BKP comprises short, simple questions with columns for learners' responses and the teacher's rating scales to measure student's prior knowledge in Biology.

The capability of the leaners to gain an understanding of concepts during instruction and score very high in cognitive tasks could be linked with their mental ability. Corroborating this statement, Babayemi (2014) reported that mental ability has a visible impact on achievement. On the contrary, Aremu and Tella (2009) reported mental ability has no visible impact onachievement. Mental ability is a display of theoretical constructs replacing functions, which are indirectly measurable through performance (Bamidele, 2000). Mental ability is the limit of a person to play out the higher mental procedures of thinking, recollecting, comprehension and critical thinking (Spearman, 2005). Ability is a general term used to allude to any normal for an individual that makes it feasible for the person in question to complete a type of exercises successfully. It refers to learned skills, talents or aptitudes presumed to exist prior to learning. A couple of general mental abilities incorporate verbal thinking, scientific thinking, spatial thinking and consistent thinking. Douglas (2007) submitted that there are general and specific mental abilities and believed that people with high level of general abilities "g" tend to be more successful in life, including at work. Some other scholars believe that specific abilities "s" such as musical, practical and emotional also play a key role in a person's success (Spearman, 2005; Bamidele, 2000). Therefore, this study investigated two modes of reflective instructional strategies(reflective inquiry and explicit-reflective strategies) on learners' conceptual change and achievement in Biology in secondary schools in Abeokuta, Ogun State, Nigeria.

1.2 Statement of the problem

Teaching and learning of Biology in senior secondary schools require great efforts on the part of the teachers to make use of effective instructional strategies that could bring about a gradual shift in learners' misconceptions to correct conceptual understanding and high achievement in the subject. Studies have shown that knowledge of Biology in secondary schools and higher institutions of learning provides leaners with an understanding of the structural and functional composition of man and other living organisms and the relationship of these organisms with their immediate environment. Biology also enables learners to acquire the knowledge required for the attainment of diverse human and societal needs in order to improve living standards. Many instructional strategies have been used by past scholars in various dimensions to correct learners' misconceptions in order to effect conceptual change in Biology. In spite of efforts made in the use of afore-mentioned strategies for conceptual change, not much success had been recorded as a lot of misconceptions are still noticed among leaners. These misconceptionsresult in poor achievement in Biology as revealed in the Senior School Certificate Examinations (SSCE) conducted forleaners yearly by West African Examinations Council (WAEC) and National Examinations Council (NECO). In view of these challenges faced in learning of Biology, it is imperative for teachers to look into a way of remediating the problem of misconceptions among students of Biology through the use of instructional strategies that could bring conceptual change. These may include reflective strategies. A number of studies had been carried out on reflective instructional strategies using pre-service teachers. There had not been much success recorded as to the extent to which other strategies such as reflective inquiry and explicit-reflective strategies influenced secondary school students' conceptual change and achievement in Biology. Therefore, it is imperative to investigate how reflective instructional strategies (reflective inquiry and explicit-reflective strategies)influencestudents' conceptual change and achievement in Biology in secondary schools.

1.3 Research questions

This research question was raised to guide the study:

What is the pattern of students' conceptual change over time in pretest, posttest and delayed posttest using reflective inquiry and explicit-reflective strategies?

1.4 Null hypotheses

This study tested the following null hypotheses at 0.05level of significance:

Ho_1: There is no significant main effect of treatment on students'

(a) Conceptual change in Biology

(b) Achievement in Biology

Ho_2: There is no significant main effect of prior knowledge on students'

(a)Conceptual change in Biology

(b) Achievement in Biology

Ho_3: There is no significant main effect of mental ability on students'

(a) Conceptual change in Biology

(b) Achievement in Biology

Ho_4: There is no significant interaction effect of treatment and prior knowledge on students'

(a) Conceptual change in Biology

(b) Achievement in Biology

Ho_5: There is no significant interaction effect of treatment and mental ability on students'

(a) Conceptual change in Biology

(b) Achievement in Biology

Ho_6: There is no significant interaction effect of prior knowledge and mental ability onstudents'

(a) Conceptual change in Biology

(b) Achievement in Biology

Ho_7: There is no significant interaction effect of treatment, prior knowledge and mental ability onstudents'

(a) Conceptual change in Biology

(b) Achievement in Biology.

1.5 Scope of the study

The population for this study were co-educational senior secondary school two (SSII) learners within Abeokuta, Ogun State. Three biological concepts were selected for the study as the formed part of contents of SSCE Biology curriculum. They are: (i) osmosis and diffusion (ii) photosynthesis (iii) cellular respiration. These concepts were selected for this study to develop scientific inquiry attitude in the learners and to guide them in linking their prior knowledge of the biological concepts to the new scientific knowledge during the teaching and learning process. Learners' conceptual change over time and achievement were measured. The moderating effects of prior knowledge and mental ability were also measured.

1.6 Significance of the study

The findings from this study would be a basis to change the perspectives of Biology learnersand ensure that they reflect on their previous experiences before learning new knowledge in order to effect a conceptual change in them. School administrators may be provided with information on the use of instructional strategies which could facilitate learners' conceptual change and achievement of Biology in senior secondary schools such as reflective inquiry and explicit-reflective instructional strategies. Findings of the study will enable teachers to understand why student-related variables such as prior knowledge and mental ability might make or mar any significant contribution to learners' conceptual change and achievement in Biology. The results from this study would also provide information for parents and guardians concerning their wards' performance in Biology. The studywould also help policy makers in formulating educational policies which would support the advancement of teachers' efficiency and effectiveness in the use of instructional strategies which may bring about conceptual change in Biology. The results obtained from this study may be beneficial to Biology curriculum planners in developing a more viable and meaningful curriculum which would indicate both teachers' and learners' activities by inquiry and experimentation during classroom instruction, making teaching more interactive and learner-centered. The validated measurement scales and assessment tools developed in this study may be of value to future knowledge evaluation. Moreover, the validated empirical data generated in this study may be useful to future scholars for further studies.

1.7 Operational definitions of terms

The following terms were defined based on their application in this study:

Achievement in Biology: This is the level of performance attained by leaners in Biology in an achievement test.

Conceptual Change in Biology: This is the restructuring of learners' knowledge of biological concepts to incorporate new information entirely to ensure long term retention of knowledge in the memory.

Explicit-Reflective Strategy: This is an instructional strategy that provides students opportunity to analyse the exercises in which they are locked in from various perspectives, to outline between their exercises and to draw generalisations about a domain of knowledge, having reflected on these activities within a framework of biological contexts.

Students'Mental Ability: Mental capacity is the abilityof students to learn or hold information. It is theability to comprehend the importance of a person's conduct which is measurable through performance.

Misconception: This refers to faulty conception of Biology concepts which are not in agreement with the scientific conception.

Reflective Inquiry Strategy: Reflective Inquiry Strategy is an instructional strategy that stimulates students to utilize new information (knowledge) to achieve authentic learning of

Students' Prior Knowledge: This means what the leaners already know about the selected topics before they entered classroom, which may be valid (correct) or invalid (not correct).

CHAPTER TWO

REVIEW OF RELATED LITERATURE

The Chapter presents a description of the theoretical, conceptual and the empirical reviews that provide theoretical, conceptual and empirical frameworksfor this study. The literature review presented under the following sub-headings:

2.1 Theoretical framework

2.1.1 Kolb's Experiential Learning Theory

2.2 Conceptual review

2.2.1 Nature of Biology Teaching and Learning

2.2.2 Students' Conceptual Change in Biology

2.2.3 Students'Achievement in Biology

2.2.4 Reflective Instructional Strategies

2.3 Empirical review

2.3.1 Reflective Inquiry Strategy and Students' Conceptual Change in Biology

2.3.2 Reflective Inquiry Strategy and Students' Achievement in Biology

2.3.3 Explicit-reflective Strategy and Students' Conceptual Changein Biology

2.3.4 Explicit-reflective Strategy and Students' Achievement in Biology

2.3.5 Prior Knowledge and Conceptual Change in Biology

2.3.6 Prior Knowledge and Students' Achievement in Biology

2.3.7 Mental ability and Students' Conceptual Change in Biology

2.3.8 Mental ability and Students' Achievement in Biology

2.4 **Appraisal of related literature**

2.1 Theoretical framework

David Kolb’s Theory of Experiential Learning provides the theoretic orientation for this study

2.1.1 Kolb’s Experiential Learning Theory (1976)

This study is anchored onDavid Kolb’s Theory of Experiential Learning. This theory supports reflective modes of teaching which are essential to the improvement of instructors as experts as it empowers learners to gain from their encounters of educating. It encourages students' learning. Creating intelligent practice means creating methods for assessing our very own instructing so it turns into a daily schedule and a procedure by which may ceaselessly create. David Kolb (1976) developed a theory of experiential finding that can give educators a significant model by which to develop teacher preparation. This is known as the Kolb cycle, the learning cycle or the experiential learning cycle. The cycle contains four one of kind periods of picking up for reality and can be entered whenever anyway all stages must be followed in a plan for productive making sense of how to occur. The learning cycle prescribes that it isn't sufficient to have an experience for making sense of how to happen. It is critical to consider the experience to make theories and figure thoughts which would then have the option to be associated with new conditions. This learning must by then be given a shot in new conditions. The learner must make the association between the speculation and action by masterminding, acting, reflecting and relating it back to the theory. Kolb's theory of experiential learning is a basic depiction of a learning cycle that shows how encounters are converted into ideas, which thus are utilized as aides in the decision of new encounters (Kolb, 1976). Kolb's theory is best known through the four-phase of experiential realizing which is alluded to as the Lewinian Experiential Learning.

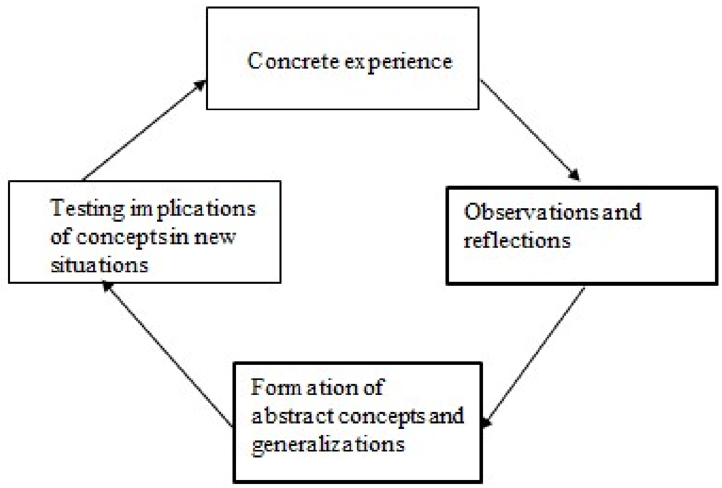


Figure 1: The Lewinian experiential learning theory according to Kolb (1984)

The Lawinian experiential learning theory is commonly known as Kolb's hypothesis, and Kolb builds his very own hypothesis with it as a beginning stage (Kolb, 1984). Kolb states that every one of the periods of the hypothesis is an "alternate type of adjustment to the real world' or a 'learning hypothesis' (Kolb, 1971). A different individual capacity relates to each period of the hypothesis (Kolb, 1984).

Kolb's experiential learning theory discusses the following attributes or abilities that learners must possess if they are to be successful in classroom learning::

(i) Concrete experience abilities (CE)

(ii)Reflective observation abilities (RO).

(iii)Abstract conceptualising abilities (AC)

(iv) Active experimentation abilities (AE)

Kolb further simplified these abilities as follows:

i Students must probably include themselves completely, transparently and without predisposition in new encounters (CE).

ii. Students must probably think about and watch their encounters from numerous points of view (RO).

iii. Students must most likely make ideas that incorporate their perceptions into consistently solid theories. (AC)

iv. Students must most likely utilize these speculations to settle on choices and take care of issues (AE).

Kolb (2013) depicted learning as the method whereby data is made through the difference in the association. According to Kolb, learning incorporates the acquisition of dynamic thoughts that can be associated with the extent of conditions. He acknowledged that the tendency for the headway of new thoughts is given by new experiences. The four stages recognized in Kolb's learning cycle are explained in this way: strong experience infers that another experience of a situation is experienced, or a reinterpretation of existing foundation; insightful observation suggests the new experience which is of explicit importance are any abnormalities between the experience and cognizance; novel conceptualization infers reflection offers rise to another idea, change of a current hypothetical thought; dynamic experimentation infers the learners apply the new arrangement to their general surroundings to see what results. As indicated by Kolb (1984) an incredible learning results when an individual experiences the four periods of having strong experience, trailed by the view of and reflection on that experience, provoking the improvement of dynamic thoughts (examination) and theories (closes) which are then finally used to test hypothesis later on conditions, realizing new experiences.

Kolb's learning cycle could be used by teachers to in a general sense survey the learning plan regularly available to students and to develop continuously fitting learning openings. Teachers should ensure that activities are arranged in such a way that suit learners best. Learners can in like manner be adjusted even more satisfactorily by perceiving their less supported learning styles and the bracing of these through the use of the experiential learning cycle. Ideally, activities and materials should be made inhabits that draw limits from each period of the experiential learning cycle and take the learners through the whole technique in gathering.

Kolb's experiential learning theoryis relevant to this study giving its four-stage learning cycle which includes concrete experience, reflective observation, abstract conceptualization and active experimentation. These stages are all involved in carrying out reflective instructional strategies which enable learners to effectively link new learning experience with their prior knowledge of scientific concepts through concrete experience, observation and reflection. Following Kolb’s theory of experiential learning, learners would be able to transform experiences into knowledge. Consequently, there would be a gradual shift from misconceptions to correct conceptual understanding, or reinforcement of correct biological concepts over a time lag which may apparently reflect in learners' performance in the subject matter and invariably improve their achievement in Biology.

2.2 Conceptual review

Concepts that are central to the focus of this study are reviewed in this section. The relationship among these concepts and how they connect to provide the framework for the study are explicated.

2.2.1 Nature of Biology teaching and learning

Understanding of nature of Biology teaching and learning will provide a range of balanced teaching and learning experiences in Biology classrooms where the teachers of Biology adopt relevant and effective instructional strategies which could enable learnersbuild up the essential organic learning and getting, abilities and processes, values and attitudes in Biologyinstruction for self-improvement and for contributing towards a logical and innovative world (Okenyi,2012; Nlewem,2012). Through the learning of Biology, learners will procure pertinent procedural and calculated information to assist them with understanding a large number of the present contemporary issues, and they will end up mindful of the interconnections between science, innovation and society. What's more, learners will build up regard for the living scene, a frame of mind of dependable citizenship and a pledge to advance individual and network wellbeing (Okenyi, 2012).

Science educational plan gets ready learners for entering tertiary courses, livelihood related courses or the workforce in different fields of life science. It gives a stage to creating logical proficiency and working up fundamental logical information and abilities forever long learning in science and innovation (Nlewem, 2012). The educational plan has in-manufactured adapt ability to provide food for the interests, capacities and necessities of learners. This ability additionally gives a way to achieve harmony between the amount and nature of learning. Instructors ought to give plentiful chances to learners to participate in an assortment of learning encounters, for example, examinations, exchanges, exhibits, down to earthwork, ventures, field considers, model-production, contextual investigations, oral reports, assignments, discusses, data search and pretend.

Teachers should offer thought to the scope of encounters that would be most suitable for their learners. The setting for learning ought to be made applicable to day by day life with the goal that leaners will encounter Biology as an intriguing and significant subject. Commonsense work and examinations are basic segments of Biology educational program. They empower learners to increase the individual experience of science through hands-on exercises Practical work and examinations additionally upgrade the abilities and thinking procedures related to the act of science (Okenyi, 2012). Investment in these exercises urges learners to carry logical speculation to the procedures of critical thinking, basic leadership and assessment of proof. Participating in logical examinations empowers learners to pick up a comprehension of the idea of science using Biology standards and hypotheses. So as to make the investigation of Biology energizing and significant, learners ought to be shown Biology, all things considered, settings by the selection of assorted learning and educating methodologies. Additionally, appraisal practices ought to be executed to invigorate premium and make inspiration for learning among learners with a scope of capacities and yearnings.

The transcendent objective of the instructive change is to get ready learners to brilliantly take an interest in popularity based society, be fruitful in the workforce and improve inclines in learners' scholastic execution contrasted with their global companions (Association of American Colleges and Universities, 2011; National Center for Education Statistics, 2007). Accomplishing the previously mentioned objective expects learners to secure fundamentals aptitudes and learning fundamental for achievement in the 21st century, and likewise to contemplate numerous present perplexing and dubious issues (National Education Association, 2014). Notwithstanding, basic reasoning isn't something that falls into place without any issues for a great many people. This is the reason instructing learners to think basically can be testing (Sinatra, Kienhues, and Hofer, 2014). Research uncovers that miens, convictions, and abilities that contain basic reasoning require epistemic discernment. Epistemic perception alludes to how individuals procure, develop, comprehend, and use learning both inside and past the study hall (Greene, Sandoval, & Bråten, 2016). When extending beyond simple memorization or the conduct of simple procedures, people must implement epistemic cognition. For example, people employ epistemic cognition when determining who or what to believe when weighing alternatives to solve complex problems. Constructivist learning has consistently been emphasised to create more student-centered classrooms.

The primary influence on teachers' instructional practices in Biology is their epistemic beliefs (Hofer, 2012). Teacher preparation programmes that create

constructivist learning environments will enhance learners' learning by building on prior
knowledge of Biology and incorporating alternative constructs that are consistent with education reform. Further, such inclusive teacher preparation programmes will extend t eaching and learning of Biology as a whole by developing teachers who possess thinki ngand reasoning skills that enable twenty-firstcentury problem solving in Biology. Of course, Biology education should closely relate real world NOS practice and experience with scientific inquiry and scientific reasoning. For leaners to be active learners in science (Biology inclusive) and real-world, authentic practices andprocedures, their teacher smust possess a sophisticated understanding of NOS and strong scientific reasoning skills.

2.2.2Conceptual change in Biology

Conceptual change is referred to as the process of overcoming the division between common sense conceptions and scientific theories. Conceptual change has been defined in numerous ways. For example, from a Piagetian perspective, conceptual change involves going through a process of accommodation, a process in which schema are ch anged when learners are exposed to new data that does not fit with their current originations (Piaget,1970). It is important to keep in mind that in accommodation, new schemas do not supersede or supplant prior schema as people simultaneously hold mult iple schemas to explain phenomenon (Shtulman, 2009). Rather, the new schema holds greater explanatory power or is more aligned with the experienced situation and therefo re is more likely to be considered and to become the dominant conception used to explain phenomenon in a given situation or context. Thus, conceptual change is defined in ways that suggest that schema are modified or restructured leading to a change in conceptions or as processes of new schema formation,yet without replacing individuals' prior knowledge.

Therefore, it could be deduced that conceptual change is building on an existing conception to form a new explanation while retaining explanation of the original extant conception. The result of the modification becomes the preferred conception, while the original conception is retained and can still maintain its validity. This is because people may hold multiple conceptions to explain a specific phenomenon (Ohlson, 2009, Shtulman, 2009).

Ideas resemble mental portrayals that, in their least complex structure, can be communicated by a solitary word or a lot of thoughts depicted by a couple of words. Using language, singular ideas would then be able to be associated with construct increasingly complex ideas. An idea in the psyche is put away as a neural circuit. Neurons structure networks of interconnected neurons.

Teaching for conceptual change is necessary to enable learners modifies their naïve idea of science to reflect the scientific ones. Similarly, teachers need to see how earlier information influences learning if they want learners to make the most of a new experience. Conceptual change is generally viewed as learning that changes an existingconception (belief, idea, or way of thinking). The shift or restructuring of existing knowledgeand beliefs is what distinguishes conceptual change from other types of learning. Learning forconceptual change is not merely accumulating new facts or learning a new skill (Abimbola,2015; Acar, 2014). In conceptual change, an existing conception is fundamentally altered or evenreplaced, and be adopted as the conceptual framework that students use to solve problems,explain phenomena, and function in their world (Abimbola, 2015). Articulating and committingto memory of the conceptual framework is necessary for the learner to continue to function. Teaching for conceptual change as reported by Davis (2002) primarily involves:

1. Uncovering learners' previously established inclinations about a specific subject or marvel, and
2. Using different techniques to enable students to change their applied structure.

Similarly, teaching for conceptual change involves engaging the learners in some tasks requiring deep reasoning, manipulation and expression of their opinion. Majority of researchers who work on conceptual change instructional methodologies have consistently been in the confine of science. Be that as it may, outside of school, learners create solid misinterpretations about a wide scope of ideas identified with non-logical areas, for example, how government works, standards of financial aspects, the utility of arithmetic, the explanations behind the social equality development, the nature of the composition procedure, and the reason for the appointive school. Theoretical change methodologies can enable learners to beat misguided judgments and learn troublesome ideas in every branch of knowledge as well as help learners to retain the acquired knowledge(Davis, 2000).

This is in line with the view that social constructivists and cognitive apprenticeship perspective have each or both influenced conceptual change (Hmelo-

Silver and Azevedo, 2006). Thus, the learners taught with the adoption of reflective strategies could be encouraged to display a higher and better learning outcome than those engaged in the conventional scheme. Notwithstanding, notwithstanding when effectively occupied with endeavouring to understand guidance, learners frequently translate and at times alter approaching boosts so it fits in with what they as of now accept. Thusly, learners' earlier information that is inconsistent with planned learning can be incredibly impervious to change. Smith (2007) contended that a portion of the more entangled learning we need to do throughout everyday life, and a ton of logical plans to gain include not adding new data to what we definitely know, yet changing the manner in which we consider the data we as of now have and growing better approaches for seeing things.

Instructing for theoretical change includes complex procedures (Yenilmez and Tekkaya, 2006) Limon and Mason(2002) recommended some essential, however insufficient conditions for calculated change. They incorporate disappointment with an as of now held thought, and another origination that is clear, conceivable and productive. Nonetheless, various different issues significant to calculated change are significant and have been condensed by Trundle, Atwood and Christopher (2007) in their longitudinal investigation of applied change as pursues:

1. A few specialists declare that calculated change alludes just too enormous changes in a student's reasonable structure, while others contend that it applies to littler changes also;
2. Changes in a student's theoretical system may happen without smothering earlier learning;
3. Reasonable change has both a transformative and progressive character;
4. The setting is significant in forming and utilizing ideas;
5. Ideas might be area specific or progressively worldwide;
6. The age of a student is pertinent to calculated change; and
7. The idea of the substance has an influence on theoretical change.

The researchers, Trundle et al., (2007), contended for a multidimensional system that uses epistemological, ontological, social and full of feeling points of view for comprehension of theoretical change. Changing learners' earlier ideas may include the production of another neural system in the learners' minds just as the overhauling of previous neural circuits (Anderson and Schonborn, 2008). It is proposed that to frame new ideas or changes old lacking ones, the learner in question needs to intentionally 'see' and "comprehend" what the problems are. This may enhance ways by which leaners learn scientific concepts meaningfully and reduce the problem of misconception of scientific concepts, especially in Biology among secondary school leaners (Anderson and Schonborn,2008). Misconception had been identified as one of the hindrances behind important and lasting learning. Investigation of ongoing examinations uncovered that numerous science subjects have misconceptions (Abimbola, 2015; Acar, 2014; Arowolo, 2012).

Functional change is the procedure whereby ideas and connections between these ideas change throughout an individual's lifetime or throughout history. Research in three unique fields, which are psychological formative brain research, science instruction and history and reasoning of science, has tried to comprehend this procedure (Chi, 2005). To be sure, the union of these three fields; in their endeavours to see how ideas change in substance and association, has prompted the development of an interdisciplinary sub-field without anyone else. This sub-field is alluded to as conceptual change (Smith, 2007). When considering calculated change, it is useful to perceive that "change" is utilized in various ways. Seeing how learners get learning keeps on being a significant issue in science instruction (Wu and Tsai, 2005). Analysts and scholars keep up that individuals learn by effectively developing their own insight, contrasting new data and their past comprehension, and utilizing these to work through inconsistencies to a handle on the new understand (Hodson and Hodson, 1998). For three decades, science instructors and scientists have emphatically upheld the points of view of constructivism on learning and educating (Wu and Tsai, 2005).There are various examinations dependent on the statements of constructivism to advance learning science (Alparslan, Tekkaya and Geban, 2003). Most of these studies used the constructivist view of conceptual change-model.

Many definitions and models of conceptual change suggest that when new conceptions are formed, they become dominant and prior conceptions are no longer considered, or even lost (Dole and Sinatra, 1998; Posner and Strike, 1982). In such models, conceptions are restructured (Dole and Sinatra, 1998), resulting in newly formed conceptions that supersede prior conceptions. Other conceptual change researchers, including Vosniadou (1994) view conceptual change as the restructuring of a personal theory or simply a theory change. Vosniadou argues that the change isa combination of cognitive processes of individuals and the social and environmental conditions that they experience. This perspective suggests that conceptions morph during the process of change rather than an individual developing new conceptions and retaining prior conceptions. In addition, Vosniadou recognizes the influence of society and environment on the learners and the process of conceptual change. It is contended that the process of conceptual change likely does not involve reconstruction of a single chunk of knowledge. Rather, we embrace the notion that the learners may retain numerous conceptions of phenomenon with the capability to accurately recall and actually apply these various conceptions effectively. Thus, the researcher supports the position of Ohlsson (2009) and maintains that rather than going through process of restructuring conceptions, learners adopt and form the new conceptions as their dominant conception to explain phenomenon, while effectively maintaining their prior conceptions in a dormant or suppressed state. Learners potentially hold multiple and competing conceptions, while this had been postulated (Ohlsson, 2009), the idea of multiple conceptions is not commonly emphasized in an existing conceptual change models. Studies on learners' conceptual change embedded in Piagetian ideas involving stage theory, clinical interviews and cognitive psychological theories.

Posner and Strike (1982)identified the importance of conceptual change with regards to science learning and restructuring learners' misconceptions and recognized a similarity between Piaget's ideas of digestion and convenience (Piaget, 1970) and the ideas of science and logical upset(Kuhn, 1962).Instructional theory has been characterized byaccommodation of new knowledge considered as the old style way to deal with applied change. Posner and Strike (1982) in their work and description of conditions necessary for conceptual change, has heavily influenced science education theory (Posner et al., 1982; Strike and Posner, 1985).

Posner *et al*. (1982) suggested that conceptual change required four preconditions:

(a) dissatisfaction must already be present in existing originations;

(b) another origination must be promptly comprehensible;

(c) the new origination must seem, by all accounts, to be conceivable; and

(d) the new origination ought to propose the likelihood of a productive research programme.

There are extensive research that investigated conceptual change processes, learning mechanisms necessary for new concept generation and educational practices thatpromo te conceptual change (Vosinadou, 2013), brain science (Wellman), history (Leinhardt and Ravi, 2008), political theory (Voss and Wiley, 2006), prescription (Kaufman, Keselman, and Patel, 2008), ecological learning (Rickinson, Lundholm, and Hopwood, 2009), and science (Vosniadou and Verschaffel, 2004). The use of conceptual change assessment tools have been found useful in measuring learners' pattern of conceptual change over time and how their prior knowledge can be shifted gradually from misconceptions to conceptual understanding (Ozmen and Demicrogh, 2003).

2.2.3 Students' Achievement in Biology

The level of performance attained by learners in Biology in an achievement test is referred to as learners' achievement in Biology. It is the gain in performance which learners have acquired with respect to the short term memory as measured by an immediate evaluation. Several researchers have identified numerous factors which affect learners' achievement in Biology, among which include the school and teacher factors, the family background individual, social incentives and socio-economic factors (Okenyi, 2012).

The teaching of Biology as a subject in secondary schools is faced with many problems.The poor academic achievement of students in Biology as indicated in the report of WAEC andNational Teachers Institute (NTI) as well as the result of state common entrance examination has become a persisted public outcry as regards the falling standard of Biology education. Sciencesubjects are already facing a problem. This is mostly in the area of availability of laboratoriesand other teaching facilities in their right number of students studying science. Biology is a veryimportant subject; it has to be given more priority (Okebukola, 2000). It enables one tounderstand himself and his intermediate environment. Nevertheless, the knowledge acquired inBiology subject is applied in many fields as Medicine, Biochemistry, Pharmacy, Microbiologyand Agriculture among others. Students' achievement in Biology subject in Senior SecondaryCertificates Examination (SSCE) has been unsatisfactory over many years (Oyetunde,2010).Therefore, there is need for Biology teachers to teach the subject in a way that studentswill be able to retain the new knowledge taught and be able to link the new ideas with theiralready existing or prior knowledge. This would go a long way in facilitating conceptual changein learners as well as improving their achievement in Biology.

Biology is taught at the secondary school level as both practical and theory. Practical work is very essential to the effective teaching and learning of Biology because it encourages active participation of learners and helps the learners to apply the theoretical materials learntto real life situations.In their study on "Effective Biology teaching", Omotayo and Olaleye, (2008) viewed down to earth Biology, as the logical investigation of the life and structure of plants and creatures and their relative condition is the genuine or exploratory set-up as opposed to abiding in the hypothesis and standards.

Findings from previous studies on conceptual change approaches and students'achievement in Biology have been performing poorly in Biology, especially in the practicalaspect on yearly basis. Nwagbor (2006) stated that students perform poorly in Biology practicalleading to their failure in Biology examinations. Similarly, West Africa Examination Council(WAEC) Chief Examiners Annual Reports (2010-2016) summarized their annual reports thatperformance of candidates in Biology fell below expectations. The report discussed thecandidates' weaknesses to be as a result of the following: poor spelling, poor observation, poormathematical skills, poor deductive reasoning, and misinterpretation of questions and poorconceptual knowledge of Biology. The chief examiner commented that "there were manycandidates who could not answer correctly a single question in section A. In most cases, theyhave wild guesses and quite unrelated answers that were sometimes not biological.According to Oyetunde (2010), under achievement of students in Biology, especially inpractical aspect, are caused by factors such as lack of well-equipped laboratory, inadequatequalified Biology teachers, limited time-table hours, poor observation, poor drawing and labelingand poor comparison of specimens, and students' poor reading culture. Also, Nwagbor (2006)and Oyetunde (2010) commented that students' under-achievement in Biology practical could beattributed to poorly equipped laboratories, inadequate Biology instructional materials, and poorunderstanding of technical terms (languages) in Biology textbooks among others.

Existing studies from foreign countries also revealed poor performance of students inBiology in secondary education. For instance, performance of students in Biology among otherscience subjects offered at various schools, has been very bad (below average for most years) forthe past seven years from 2006 to 2012 in Lesotho high schools. In 2006 only 16.967% oflearners who sat for examination obtained credits while 20.07% obtained passes and about56.96% failed. In 2007 there was a slight difference in performance. About 20.55% of learnersobtained credits, 27.99% obtained passes while 50.87% failed. For those two years, performancewas poor because more than 50% of the learners failed and others could only manage the score33‘pass’ which is the lowest score, below the entry requirement for tertiary institutions(Examination Council of Lesotho, 2012).

In 2008, again, there was a positive change in performance though small. ExaminationCouncil of Lesotho 2012 says 22.10% obtained credits, 30.88% obtained passes and 47.02%failed. One could expect better results on the years that followed especially on the basis thatteacher had familiarized themselves with the syllabus, and methods of assessment. Teachers willalso have read the examination reports provided by Cambridge International Examinations (CIE)and made use of the recommendations provided. However, in 2009 there was a dramatic drop inBiology performance. There were 5.26% credits less than in 2008, 3.06% less passes than in2008 and an increase in fail of 8.32% more than what had been in 2008. In 2010, Biology resultswere worse than the previous years. Performance was falling at a faster rate than before. Thepercentage of credits dropped to 16.58%, the percentage of passes to 27.92%, and the percentageof fail increased to 55.48%. In 2011, Biology results showed the same falling trend. Thepercentage of credits dropped by 3.77% compared with 2010 results when credits were at16.58%. The percentage of passes had decreased by 0.73% and the number of failures hadincreased by 4.5% more than what had been the case in 2010. Comparing 2011 results with theresults of the other years, performance in Biology was indeed worse since it was only in that yearwhen most learners failed. About 59.98% learners failed.A positive change in the performance of Biology was, however, recorded in 2012. Thepercentage of credits rose to 22.31%, passes to 33.55%, and fail was at 44.14%. In comparison,2012 results were better than the other past six years. Most learners had performed better thoughmost scored passes. Pass scores deny learners the chance of pursuing their studies further insciences. For the previous seven years, performance in Biology had been deteriorating frombetter to worst in Lesotho at Cambridge Overseas School Certificate level.For five years: 2006,2007, 2009, 2010, and 2011 more than 50% of learners who sat for Biology failed. It was onlyfor the two years 2008 and 2012 whereby more than 50% of the learners who sat for Biologypassed. Most of them only achieved passes. Pass scores do not satisfy the requirements fortertiary institutions for those who want to pursue their studies in sciences in Lesotho. Due tostudents’ under-achievement in Biology, especially in practical aspects. Okenyi (2012) gave the following suggestions as criteria for improvement of learners’ performance in Biology as well as Education standards in

Lesotho, which could help immensely in improving teachers' modes of teaching in Biology for conceptual change and high achievement of learners in secondary schools:

1) Adequate preparation of teachers
2) Creating a conducive teaching-learning environment
3) Ensuring methodological adequacy
4) Proper handling of examinations
5) Massive investment in Biology education
6) Institutionalizing of In-service Training of Biology teachers
7) Close monitoring and supervision of school activities by the government
8) Adequate remuneration for Biology teachers
9) Every educational stakeholders must be an agent of change
10) Emphasis must be on learning, not just a grade in an examination or a certificate
11) Accreditation of educational programs
12) Re-certification which makes it obligatory for teachers at all educational levels to renew or update their knowledge and skills in Biology.
13) Public-private partnership in the funding of education
14) Professionalization of teaching in Nigeria to ensure that only qualified and trained teachers who are properly registered in Teachers' Registration Council of Nigeria (TRCN) get employment for teaching.

2.2.4 Reflective instructional strategies

The idea of intelligent instructional methodologies comes from Dewey's thought of correlation of routine activity with intelligent activity. As indicated by Dewey (1933) in Pollard (2005) routine activity is guided by customary propensity, specialist, institutional definitions and desires. By suggestion, it is generally static and inert to changing needs and conditions. Intelligent activity, then again, includes an eagerness to take part in self-examination and advancement. It suggests ability, thorough examination and social mindfulness. At the point when intelligent activity is created and connected to instructing and learning process, it becomes a challenging and exciting practice, hence referred to as reflective instructional strategies (Ige and Kareem, 2012). Ogunbameru and Raymond (2012); Ogonor and Badmus (2010) and Tanner and Allen (2005) have identified the practice of reflective teaching and learning to be characterized by the following:

i. Active and concerned with points and outcomes.
ii. Applied in a recurrent or winding procedure in which educators screen, assess and modify their own training consistently.
iii. Requires skill in strategies for proof based study hall enquiry to help the dynamic advancement of higher benchmarks of instructing.
iv. Requires a frame of mind of liberality, duty and entire heartedness.
v. Based on the instructor's judgment educated by proof-based enquiry.

Reflective instruction is a practice in which one's action on teaching is subjected tocritical thinking, analysis and evaluation. Raimi (2002) acknowledged that the practice is anattitudewhich involves stopping, slowing down, noticing, examining, analyzing and inquiringabout aspects and complexities encountered in different teaching situations. Jessey-Bassey(1995) referred to the practice as an activity or process in which an experience is recalled,considered and evaluated. Reflective teaching is a response to past experience and involvesconscious recall and examination of the experience as basis for evaluation and decision makingas a source for planning and action (Farrell, 1998).Scholars have given various definitions to reflective teaching. Hall (1997) defines it as apractice in teaching in which the teacher undertakes deliberate and sustained critical thinking andevaluation on actions for the purpose of improvement. Reflective teaching requires a teacher to have awareness of classroom experience through observation, self-inquiry and critical thinking(Kareem, 2014). The use of observation and critical thinking on what and why questions give anindividual teacher a certain power to determine the level of control that can be exercised overclassroom practice. This in a way brings about a deeper understanding of the teacher's ownteaching style, validation of a teacher's ideals and ultimately brings about greater effectivenessas a teacher which leads to professional development. Minott (2009) supported this view anddefined reflective teaching as an attitude of self-inquiry into one's practice and development ofknowledge based on inquiry which is to observe and refine practice on an ongoing basis, thus resulting in continued professional growth. Regular inquiry into a teacher's practice of teachingcould lead to regular refinement and flexibility in the teacher's classroom management, teachingand learning processes and learners' achievement. The regular inquiry in reflective teachingcould be applied using various strategies.

According to Polat (2013), reflective teaching requires supporting elements:

i. Providing learners with information and beginning the lesson in an open-ended, non-threatening way.

ii. Promoting a spirit of cooperation rather than competition and avoiding any comparisons of performance among learners

iii. Focusing on improvement rather than displays of capability

2.3 Empirical review

This section presents literate review of related empirical studies relevant to this study.

2.3.1 Studies on Reflective Inquiry Strategy and students' conceptual change

Although reflective inquiry has been promoted for many years as a progressive and effective method of teaching, its incorporation into classroom practice remains questionable. Ross and Hanna assigned part of the blame to those interpreters of Dewey's inquiry model who advocated a procedural or technical rather than a dialectic approach to thinking. Teacher education practices also contribute to the lack of critical reflection existing in schools. Too frequently the rationale for reflective teaching is expounded through expository techniques and a technical inquiry approach.The authors argue that the university classroom must become not only the venue for transmitting traditional knowledge on teacher education but also a laboratory where such practices are modelled, experienced, and reflected upon. Such a truly reflective inquiry model needs to be firmly grounded in critical theory by incorporating the application of principles, not procedures, in the investigation of social issues

Kose, Ayas and Usak (2006) conducted a research work the effect of conceptual change texts on overcoming the misconceptions about photosynthesis and respiration in plants for prospective science teachers were investigated. The sample of this study consisted of 100 prospective science teachers from the two classes of Department of Science Education in Fatih Education Faculty in Karadeniz Technical University, in Trabzon in Turkiye. The findings indicated that most of the prospective science teachers had misconceptions about photosynthesis and respiration of plants. This study proved that for prospective science teachers understanding and overcoming misconceptions about concepts of "photosynthesis and respiration in plants". The conceptual change texts, when compared with the conventional strategy of teaching the concepts, are more effective.

Okebukola (1990) examined the efficacy of the concept-mapping strategy was tried out in this study with 138 pre-degree biology students. The results showed that the

63 students in the experimental group who employed the concept-mapping technique performed significantly better on the test of meaningful learning in genetics, $t(136) = 16.01$. $p < 0.001$, and ecology, $t(136) = 12.27$, $p < 0.001$, than their control group counterparts ($N = 75$).

Demırcıoğlu (2009) examined whether the application of conceptual change texts are effective before or after the instruction on 10th grade students' conceptual understanding and alternative conceptions about acids and bases. The study was conducted with 76 10th grade students from three classes of a chemistry course taught by the same teacher. One of the classes was randomly assigned to the control group (N=25), who were taught with traditional teaching methods, and another class was randomly assigned as experimental group 1 (N=26), who studied the conceptual-change texts before the traditional teaching. The other class was randomly assigned as experimental group 2 (N=25), and studied the conceptual change texts after receiving traditional teaching. The data was collected by the Concept Achievement Test, administered as pre-test and post-test. The analysis of covariance (ANCOVA) is used to analyze the data. The analysis revealed that the differences between the results in both the experimental groups and in the control group were statistically significant.

Trundle, Atwood and Christopher (2007) examined longitudinal study of 12 female elementary pre-service teachers' conceptual understanding over the course of several months. Participants were interviewed on their understanding of the cause of moon phases before instruction, 3 weeks after instruction, and again in delayed post-interviews several months after instruction. Patterns and themes in the participants' conceptual understanding were identified through constant-comparative data analysis. Consistent with results reported earlier, participants who had instruction that included recording and analysing moon observations over time and psychomotor modelling of changes in moon phases were very likely to hold a scientific conceptual understanding shortly after instruction. The present study indicates a majority of participants continued to hold a scientific understanding six months or more after instruction. However, some participants reverted to alternative conceptions they had shown during the pre-interview. These results are interpreted utilizing contemporary conceptual change theory.

Loh, Reiser, Radinsky, Edelson, Gomez, and Marshall (1995) conducted a study on a group of students who decided to investigate Pluto's erratic orbit around the

Sun. Their goal is to set up computer simulations with different configurations of planets orbiting the sun to determine which planet has an effect on Pluto's orbit (e.g., a simulation with only Pluto and the Sun; a second simulation with Pluto, Neptune, and the Sun, etc.). They gather some information about Pluto, the Sun, and other planets, such as mass, distance from the sun, length of an orbit, etc., and plan on using these values to set up the simulation. They have been working with the teacher to develop this basic research methodology, and everyone, including the teacher, is satisfied with the viability of this approach. But when the students began to set up the simulation using the simulation environment Interactive Physics, they started encountering problems. There is a significant mismatch between the information they gathered and the variables they can change in the simulation.

The students are overwhelmed by the number of variables and do not know which to try and which are irrelevant. Should they change the gravitational constant, orbital velocity, xy coordinates, initial velocities, mass, or diameter? Moreover, the units of measure of the information they gathered are different from the units of measure used by the simulation (e.g. the data they collected was in kilometers per year, whereas the simulation required meters per second), adding another level of complexity. 10 Developing Reflective Inquiry Practices: A Case Study of Software, the Teacher, and As the students try different values, it soon became clear that it is a challenge to simply get any object to orbit another object, let alone set up a simulation that reflects the dynamics of our solar system. As they try to figure this out, the students set a variable and then run the simulation to see if it worked. But because some of the values were wrong, or some variables were overlooked, planets would fly into the Sun, or shoot off into space. So the students change a second variable, and run the simulation again.

When that also does not work, they tweak the simulation, and try another value. Since nothing works, the students feel that they never find any of the "right" answers or relevant results, so they do not write anything down. At the end of the class, when the teacher comes around to check their progress, she finds a struggling group of students who are somewhat able to articulate what they are doing but have no record of their work over the course of the period. The students have clearly been working throughout the period, but is their struggling a sign of progress or haphazard thrashing? How can the students learn from what they have explored so far to decide on the next steps of the investigation? This example illustrates the kinds of challenges that arise when students do inquiry in science classrooms. Opening up laboratory work to student-generated questions and methodology means that students are not always going to "succeed" in their projects.

The challenges presented by this example represent a progression of opportunities for learning and some partial success, rather than a project that failed completely. Students need to learn inquiry skills that help them to systematically pursue a solution to their question and to better manage their process of inquiry. To be successful in inquiry, they needed to develop new habits and new conceptual frameworks that redefine the pursuit of science as a process of constructing new knowledge rather than a search for simple answers. Seeking to understand the skills, the requisite dispositions, and the mechanisms for helping students develop into reflective inquirers is the goal of the Supportive Inquiry Based Learning Environment project (SIBLE). The researchers conducted iterative design research on the challenges faced by students as they work in information-rich environments and how their development of investigation skills can be facilitated through interactions with a software support tool and the classroom teacher. The researchers developed a software support tool, called the Progress Portfolio, as an integral part of this research process.

This study aimed at investigating how to craft not just the software to foster reflective inquiry, but all the variables and the materials used in the course of the study. The researchers described the first iteration of the software design, and through a case study, explored how these tools could be integrated into the practices of an existing curriculum project.Loh, Reiser, Radinsky, Edelson, Gomez, and Marshall (1995) variables were relevant, embarking on a haphazard trial-and-error approach to solving the problem.

2.3.2 Studies on Reflective Inquiry Strategy and Students' Achievement

Ige and Kareem (2012) examined the effects of two reflective teaching strategies on secondary school teachers' classroom practices and students' achievement in biology in Ibadan. The study adopted a pretest-posttest, control group, quasi-experimental design using a 3x2x2 factorial matrix. Eighteen Senior School II biology teachers and intact classes of 576 students in all were drawn from nine selected secondary schools in Ibadan metropolis. Seven instruments were used to collect data. Data were analysed using descriptive statistics, Analysis of Covariance (ANCOVA) and Scheffe post hoc test at 0.05 level of significance. The results revealed that treatment had significant main effects on students' achievement and classroom practices.The author recommended that the two strategies should be used by biology teachers for improved students'achievement.

Moango (2015) investigated on the influence of reflective inquiry-based teaching on public secondary school students' performance in geography map work in Kenya. The purpose of this study was to investigate the influence of reflective inquiry-based teaching on public secondary school students' performance in geography map work in Kenya. The study targeted both the teachers and Form 3 students in public secondary schools in Nyanza, Western and Rift Valley regions in Kenya. Quasi-experimental research design was used to guide this study. Data was collected using questionnaires, document analysis, interviews, observation, pre-test and post-test methods. During data collection, adequate steps were taken to preserve the integrity and identity of the participants including procuring consent to carry out the study. Data was analysed using means, standard deviations, percentages, t-test and analysis of variance (ANOVA). The findings indicate that there is a significant difference in students' performance in geography map work ($t(236) = 22$, $p < 0.05$) between students who were taught using reflective inquiry-based teaching method and those taught using conventional methods of teaching geography map work in public secondary schools. This implies that public secondary school students are likely to perform better in map work activities when taught using reflective inquiry-based method in addition to the conventional methods of teaching geography map work. The study also established that teacher qualifications positively influence students" performance ($F(3,115) = 1.295$, $p=.828$) in geography map work. Findings also indicate that students have positive attitude towards map work activities ($F(2, 236) = 132.38$, $p=1.26$) when taught using reflective inquiry in addition to the conventional methods of teaching geography. Against these findings, there is need to have teachers and instructional supervisors of geography trained in reflective inquiry-based teaching method and also have instructional materials that incorporate this method of teaching in schools. The findings are also likely to inform curriculum developers on use of reflective-inquiry-based teaching method in teaching school geography map work. Consequently, further research is recommended on reflective inquiry-based teaching to determine the steps on how it can be integrated in secondary school system.

Ogbuanya and Owodunni (2015) investigated a study designed to determine the effect of reflective inquiry instructional strategy on achievement of students in Technical Colleges. The study adopted a pre-test, post-test, non-equivalent control group, quasi experimental research design which involved groups of students in their intact class assigned to experimental group and control group. The population of the study was 105 Tech II students of and Electronic Works trade in Technical Colleges in Lagos State. Four research questions and five null hypotheses, tested at 0.05 level of significance, guided the study. The instruments used for data collection were Electronic Works Achievement Test (EWAT). To ensure content validity of the EWAT, a table of specification was built for the test. The reflective inquiry lesson plan, EWAT and the training manual were subjected to face validation by three experts. The EWAT was trial-tested to determine its psychometric indices and reliability coefficient. The trial test for determining the coefficient of stability of the EWAT was carried out using test re-test reliability technique. Pearson Product Moment Correlation coefficient of the EWAT was found to be 0.83. Mean was used to answer the research questions; while ANCOVA was employed to test the hypotheses. The study found out that reflective inquiry instructional strategy is more effective in improving students' achievement in Electronic Works trade than conventional method. There was an effect of gender on students' achievement in Electronic works trade favouring boys. The study found out that there are no interaction effects of reflective inquiry instructional technique and gender on achievement of students in Electronic works trade. This simply means that the effectiveness of reflective inquiry instructional technique on students' achievement in Electronic works trade does not depend on gender. The study found out that there was an interaction effect of students' gender and their ability with respect to their mean scores on Electronic works trade achievement test. This simply means that reflective inquiry instructional technique is more effective in improving students' achievement in Electronic works trade regardless of gender or ability level. Consequently, it was recommended that The National Board for Technical Education (NBTE) should carry out a review of Electronic works trade curriculum for Technical Colleges with a view to incorporating the reflective inquiry instructional strategy into the teaching of Electronic works trade.

Sylvanus (2017) examined the effects of guided inquiry method on achievement of chemistry students in selected senior secondary schools in Kaduna state. The study used a quasi- experimental research design. A sample of 120 SS2 chemistry students were selected by random sampling technique from 2 urban and 2 rural schools which comprised both boys and girls with 30 students each in experimental and control groups respectively. The research instrumentcomprised Chemistry Achievement Test (CAT). The CAT contained 30 multiple choice questions with four options (A-D) and 5 essay questions. The students were divided into two groups: experimental and control groups which were subjected to inquiry method and traditional method respectively. The t-test statistics were used to analyse the data. Major findings revealed that chemistry students taught using the inquiry teaching method performed significantly better than their counterparts taught using the traditional method. Hence, the study concluded that the inquiry teaching method produced students with significantly higher achievement in Chemistry. The study therefore recommended among others that the use of Inquiry teaching method should be encouraged in all secondary schools in Kaduna State in Nigeria

Tümen and Çetin (2016) investigated the effect of the cognitive coaching-supported reflective teaching approach in English language teaching on the academic success of students and on the permanence of success. It was conducted during the spring semester of 2013/2014 academic year at the School of Foreign Languages, Firat University, Elazig, Turkey. The study was conducted using pre-test/post-test control group design, which is one of the true score models, and it lasted 7 weeks. During this process, lectures were taught using some activities based on the cognitive coaching-supported reflective teaching approach in the experimental group, and the traditional approach was used in the control group. As a data collection method, a test developed by the researcher was applied. Three weeks after the ending of the experimental study, a permanence test was applied. According to the results obtained from this study, it can be stated that the cognitive coaching-supported reflective teaching approach in teaching of the English language is an effective method for increasing students' academic success and permanence.

Arowolo (2012) investigated the use of two conceptual change strategies (Simplex and Cognitive Coaching) and the moderating influence of mental ability and self-concept on students' learning outcomes in Basic Science. The study employed a pretest-posttest, control group, quasi-experimental design, using a 3 x 3 x 2 factorial matrix. Intact classes made up of two hundred and twenty three students, having high, medium and low mental abilities, from six secondary schools in Kwara state were randomly selected. Eight instruments were used for this study: Teacher's Instructional Guides for: Simplex, Cognitive Coaching and Conventional method; Basic Science Concepts Achievement Test ($r = 0.73$); Attitude towards Basic Science Scale ($r = 0.83$); Mental Ability Test ($r = 0.67$); Self-Concept Inventory ($r = 0.79$) and Basic Science Conceptual Change Debriefing Protocol ($r = 0.67$). Two research questions were answered and seven null hypotheses were tested at the 0.05 level of significance. Data were analysed using Descriptive statistics, Analysis of Covariance (ANCOVA), Scheffe post hoc test and graphs. The two teaching strategies had significant effect on achievement in ($F(2,204)=10.624$; $P <.05$), attitude towards ($F(2, 204) = 4.360$; $P < .05$) and retention of ($F(2,204)=32.602$;$P<.05$) Basic Science concepts. Students exposed to Simplex strategy had the highest post-test mean score (= 9.32) on achievement in Basic Science concepts, followed by those of the Cognitive Coaching strategy (= 8.85) and the Conventional method (= 7.68). The students taught with Conventional method had highest mean score (= 53.28) than the Cognitive Coaching strategy (= 48.69) and the Simplex strategy (= 46.55) on attitude towards Basic Science concepts. For retention of Basic Science concepts, Simplex group had highest mean score (= 7.84) than the Cognitive Coaching group (= 7.67) and the Control group (= 4.91). Simplex and Cognitive Coaching strategies were effective in causing conceptual change and improving students' learning outcomes in Basic Science. Basic Science teachers should therefore, use Simplex and Cognitive Coaching strategies for enhancing students' learning outcomes in Basic Science.

Hasan (2012) investigated on the Effects of Guided Inquiry Instruction on Students' Achievement and Understanding of the Nature of Science in Environmental Biology. The purpose of his study is two folds: 1) to investigate students' views of the nature of science based on the newly implemented science curriculum, the Hartcourt International, in United Arab Emirates' (UAE) public schools and 2) to investigate the impact of guided-inquiry of instruction in teaching the environmental biology subject and the Nature of Science aspects with students. Seventy six tenth-grade students distributed amongst 4 mutual exclusive classes participated in this study. The respective classes were randomly divided into two intact groups: experimental and control groups. The experimental group was taught using the guided inquiry instruction during theoretical classes and laboratory activities, which based on grappling with guided-inquiry questions and practicing science as process skills. The control group was taught using the traditional strategy, without incorporating the guided inquiry instruction and the science process-skills. A modified Nature of Science scale adopted from Wenning (2006), Iqbal et al. (2009) and the doctorate thesis of Larson-Miller (2011), and an environmental biology achievement test from the Hurtcourt International biology assessment guide book were used as pre and post-tests for measuring the effect of guided inquiry instruction on both students' nature of science conceptions and biology achievements respectively. Results reveal that the students' nature of science conceptions in the pre-case are still wanting. Moreover, implementing the guided inquiry instruction in teaching the environmental biology subject has significant effect in improving the students' academic achievement. However, this kind of instruction alone seems to be insufficient in developing nature of science conceptions in the students. Differences in the total average scores between pre- and post- nature of science scale are not statically significant for both the experimental and control groups. It is possible that more explicit instructional approaches are needed to be investigated for their effectiveness in achieving nature of science understandings in students' minds.

Agboghoroma and Oyovwi (2015) evaluated the effect of students' academic achievement on identified difficult concepts or topics in Senior Secondary School Biology in Delta State, Nigeria. The study was quasi-experimental and the design was a 2X2 factorial non-randomized pretest-posttest control group design. The sample was drawn from intact classes from four coeducational schools located in urban and rural centres in Delta Central Senatorial District. A total of 160 male and female students were used in the study. The sample were got using purposive sampling technique. The instrument for the study was designed by the researchers and tagged Biology Achievement Test (BAT). This was validated by experts and Kuder- Richardson formula 21 was used for the reliability estimate and this yielded 0.71 alpha. This was tested at 0.05 significant level. The methods used for evaluating the students was Conceptmapping and the Regular Teaching Methods, as experimental and control groups respectively. The results showed that students perceived some topics like Hereditary, Genetics, Ecology as difficult while it was found out that gender (male and female sex) and school location (urban and rural) had no effect on difficult concepts in Biology. Based on these, recommendations were made; such as innovative teaching strategies like concept mapping be used in our classrooms.

2.3.3 Studies on Explicit Reflective Strategy and Students' Conceptual Change

Abd-El- Khalick (2001) investigated the influence of an explicit reflective inquiryinstructional strategy compared with an implicit inquiry instructional strategy on sixth graders' understandings of nature of science. The study emphasized the tentative, empirical, inferential, and imaginative and creative nature of science. Participants were 62 sixth-grade students in two intact groups. The intervention or explicit group was engaged in inquiry activities followed by reflective discussions of the target nature of science aspects. The comparison or implicit group was engaged in the same inquiry activities. However, these latter activities included no explicit references to or discussion of any nature of science aspects. Engagement time was balanced for both groups. An open-ended questionnaire in conjunction with semi-structured interviews was used to assess participants' nature of science views before and at the conclusion of the intervention, which spanned 2.5 months. Before the intervention, the majority of participants in both groups held naive views of the target nature of science aspects. The views of the implicit group participants were not different at the conclusion of the study. By comparison, substantially more participants in the explicit group articulated more informed views of one or more of the target nature of science aspects. Thus, an explicit reflective inquiry strategy was more effective than an implicit inquiry strategy in promoting participants' nature of science conceptions. These results do not support the intuitively appealing assumption that students would automatically learn about nature of science through engagement in science-based inquiry activities. Developing informed conceptions of nature of science is a cognitive instructional outcome that requires an explicit reflective instructional strategy.

Bautista and Schussler (2010) investigated on implementation of an explicit and reflective pedagogy in introductory biology laboratories. The researchers implemented the explicit reflective pedagogical approach during the first semester of a year-long biological concept course at a mid-western public university. The four credit- course consists of lecture (150 minutes per week) and laboratory activities (110 minutes per week), which comprises 25% of the course grade. The lecture covers the topics of ecology, evolution, genetics and the diversity of life. The laboratory topics roughly follows the content of the course and gives students opportunity of formulating hypotheses, designing experiments, performing laboratory skills and analysing data. The lecture classes were team- taught by professors from the botany, microbiology and zoology departments; the laboratory classes were taught by the biology graduate assistants. For each laboratory exercise, nature of science learning objectives 1 and 2 were presented to the students, and a list of in-class discussion and post-laboratory reflection questions were used by graduate assistants to lead student discussions. Through this didactic method, students were learning by teaching their peers a common practice in educational theory in which the teacher's own learning is improved because they are required to retrieve information that they have previously studied. The value of this reflective pedagogical approach is that it brings the student learning experience full-circle and helps them to achieve a deeper understanding of the nature of science. Interviews carried out revealed a range of approaches to supporting both graduate assistants and undergraduate assistants. The data presented were part of a research study funded by the National Science Foundation that implemented an explicit reflective instructional approach in graduate assistant-taught inquiry and expository laboratory treatments associated with three large introductory biology lecture classes and investigated the impact of this approach on undergraduate understanding of nature of science. The design and implementation of an explicit reflective approach for teaching nature of science in college biology laboratories and the impact of this strategy as assessed by both quantitative and qualitative methods on undergraduate students' and specific understanding of various nature of science aspects were reported in detail elsewhere. Findings from this study indicated that an explicit reflective curriculum can be designed for these introductory biology laboratories, but that the effectiveness of the pedagogy on student nature of science understanding varied depending on the laboratory treatment and nature of science aspect being assessed. This study further revealed that the explicit reflective instructional strategy is not difficult to integrate into current inquiry-based science laboratories and can be successfully implemented by graduate teaching assistants. However, convincing students of the importance of learning about nature of science is difficult and may be the most important factor in the effectiveness of this strategy.

Pekbay and Yilmaz (2015) investigated on the effect of explicit-reflective and historical approach on pre-service elementary teachers' views of nature of science.This study aims to explore the influence of nature of science activities based on explicit-reflective and historical approach on pre-service elementary teachers' views of nature of science aspects. Mixed-method approach including both qualitative and quantitative methods was used. The sample consisted of 83 pre-service elementary teachers of a public university. Activities in experimental group were prepared as per explicit-reflective approach, whereas per historical approach in the other group. Views of nature of science questionnaire was applied both as a pre-test and post-test to explore students' views about nature of science aspects. During a 3-week application, worksheets were used and we benefited from observation checklists to control potential threats to internal validity. While content analysis method was used in qualitative analysis; frequency, percentage, Wilcoxon sign and Mann-Whitney tests were facilitated in quantitative part. Results indicated that students who experienced explicit-reflective instruction made statistically significant gains in their views of nature of science aspects and accordingly some implications were presented.

Driver (1985) laid the groundwork for literally hundreds of studies on students' conceptual understanding and misconception in many scientific disciplines. In her methodological approach to studying misconception, the goal of this study was to look in detail at individual students' explanations of scientific phenomena through in-depth interviews in which the students' ideas could be probed and prodded much more extensively than any paper-pencil assessment ever could. Through this approach using detailed student interviews, Driver (1985) revealed student conceptions that were surprising to most experts in the sciences, including conceptions about the essence of living things; the movement of the earth in space; the nature of light, water, and air; the relationship between heat and temperature; and the processes of chemical change, to name but a few. Her insights shed light on what was conceptually difficult for science novices, something that most science experts are blind to because of their own familiarity with and ease of understanding of the subject matter. Driver's work established a new field of educational research that has been important since its inception, influencing both traditional educational researchers and scientists-cum-discipline-based science education researchers. Although the studies initiated by Driver and her colleagues have produced an impressive literature on student alternative conceptions in general, the field of research into alternative conceptions in biology is still emerging as compared with efforts in the physical sciences.

Anderson *etal.* (2002) developed a Conceptual Inventory of Natural Selection (CINS) that employed known alternative conceptions as “wrong answers” in a multiple-choice assessment tool. Presenting actual scientific studies of natural selection, such as the work on the Galapagos finches and on Great Britain's peppered moth as scenarios, the CINS is a 20-item multiple-choice instrument. In the design of this assessment, the authors identified a scientific concept for assessment and also utilized known alternative conceptions. For example, in assessing students' understanding of the role of changes in populations over time in natural selection, Anderson *etal.* (2002) used the sample question from the CINS, which uses “wrong answers” as distracters.In acknowledgment of this model, strategies collectively known as “conceptual change approaches” are generally, but cautiously acknowledged as being more successful in this regard than traditional ones. Finally, teaching toward conceptual change requires, more generally, ongoing and varied means of assessing student understanding in the course of instruction.

Taber (2001) interviewed college students enrolled in a 16-week chemistry course. One of the interviewees used three different explanatory principles when probed for his understanding of chemical bonding in different contexts. The researcher used each explanation many times in the course of the semester, or sometimes moved among all three, assigning explanatory power to each in the course of a single interview. In other words, students may have multiple and layered explanations of a single concept, the complexity of which may not surface in response to an assessment strategy that requires only that students have memorized the “right answer. In conclusion of this study, Taber (2001) identified that teaching science for understanding is strongly informed by the ideas that have emerged from conceptual change theory in the educational research literature. In his recommendation, explicitly uncovering and addressing students' prior and alternative conceptions in biology should be encouraged by the teacher in order to integrate new ideas into existing conceptual frameworks about how the natural world.

Akerson, Abd-El- Khalick and Lederman (1999) assessed the influence of a reflective explicit activity-based approach to nature of science instruction undertaken in the context of an elementary science methods course on pre-service teachers’ views of some aspects of nature of science. These aspects included the empirical, tentative, subjective (theory-laden), imaginative and creative, and social and cultural nature of science. Two additional aspects were the distinction between observation and inference, and the functions of and relationship between scientific theories and laws. Participants were 25 undergraduate and 25 graduate pre-service elementary teachers enrolled in two sections of the investigated course. An open-ended nature of science questionnaire coupled with individual interviews was used to assess participants' nature of science views before and at the conclusion of the course. The majority of participants held naive views of the target nature of science aspects at the beginning of the study. During the first week of class, participants were engaged in specially designed activities that were coupled with explicit nature of science instruction. Throughout the remainder of the course, participants were provided with structured opportunities to reflect on their views of the target nature of science aspects. Post-instruction assessments indicated that participants made substantial gains in their views of some of the target nature of science aspects. Less substantial gains were evident in the case of the subjective, and social and cultural nature of science. The results of the present study support the effectiveness of explicit, reflectivenature of science instruction.

2.3.4 Studies on Explicit Reflective Strategy and Students' Achievement

Oka and Abba (2020) investigated the effects of explicit learning strategy and learning styles on students' achievement in Basic Science in Nasarawa State, Nigeria. Quasi experimental procedure was adopted for this study. Four research questions and four null hypotheses guided the study. The population of this study comprised 2321 Senior Secondary school students in North Senatorial District of Nasarawa State, Nigeria. The sample consisted of 82 (35 students for the experimental groups and 47 students for the control groups). Index of Learning Style Questionnaire (ILSQ) and Biology Achievement Test (BAT) were the instruments used to gather data for this study. Test-retest approach was used to establish the reliability of ILSQ and the results obtained were subjected to Pearson Product Moment Correlation. The result showed that ILSQ has a reliability coefficient of 0.77. The results obtained from BAT were subjected to Kuder-Richardson formula -21 (KR21) and the result showed a reliability coefficient of 0.83. Data collected were analyzed using mean and standard deviation to answer the research questions and ANCOVA was used to test the hypotheses at 0.05 level of significance. The result obtained revealed that there was significant difference in the mean achievement scores of students exposed to explicit reflective instructional strategy and Conventional method. Students in the explicit reflective instructional strategy significantly achieved better than their counterparts in the control group. Also, findings from this study revealed that the Biology students with the four learning styles (Sensing/Intuitive, Active/Reflective, Visual/Verbal and Sequential/Global) differed significantly in their achievement after being exposed to explicit reflective instructional strategy and conventional method. Based on the findings of this study, the following recommendations are made. Explicit learning strategy should be adopted in secondary schools to improve students' achievement in Biology and teachers of Biology should find out about the learning styles of their students and bear these varied styles in mind when planning and executing instruction in Biology classes.

Deringöl (2019) examined the relationship between reflective thinking skills and academic achievement in mathematics in fourth-grade primary school students. This study was conducted with the aim of determining the relationship between reflective thinking skills and academic success in mathematics in fourth-grade primary school students. The data were collected using the "Reflective Thinking Skills Scale" adapted from Demirbaş (2012), and the "Personal Information Form" developed by the researcher. The data that were collected in this study which was conducted as a screening model were analysed with SPSS 16. In the study, it was found that the reflective thinking skills of the fourth-grade primary students were high, the female students had higher reflective thinking levels than the male students, and there was a positive relationship between the reflective thinking skills of the students and their achievement in mathematics.

2.3.5 Studies on Prior Knowledge and Students' Conceptual Change

Uzuntiryaki and Geban (2005) examined on the effect of conceptual change approach accompanied with concept mapping on understanding of solution concepts. The purpose of this study was to investigate the effect of conceptual change texts accompanied with concept mapping instruction, compared to conventional instruction on 8th grade students' understanding of solution concepts and their attitudes toward science as a school subject. Solution Concept Test was developed as a result of examination of related literature and interviews with teachers regarding their observations of students' difficulties. The test was administered to a total of 64 eighth grade students from two classes of a general science course, taught by the same teacher. The experimental group received the conceptual change texts accompanied with concept mapping in a lecture by the teacher. This instruction explicitly dealt with students' misconceptions. It was designed to suggest conditions in which misconceptions could be replaced by scientific conceptions and new conceptions could be integrated with existing conceptions. The control group received conventional instruction in which the teacher provided instruction through lecture and discussion methods. The results showed that conceptual change text accompanied with concept mapping instruction caused a significantly better acquisition of scientific conceptions related to solution concept and produced significantly higher positive attitudes toward science as a school subject than the conventional instruction. In addition, logical thinking ability and prior knowledge were strong predictors for students' conceptual change in general science.

Tanner and Allen (2005) investigated on conceptual approaches to Biology Teaching and Learning. The goal of writing this paper is to describe some of the obstacles that common-sense reasoning throws in our path when we try to think about evolution. Most of this research is in very early stages; no one has anything remotely resembling a cure-all answer to these challenges. However, perhaps to help educators recognize seemingly odd or bull-headed thinking as clues to very powerful (and fascinating!) psychological processes that can allow us to get inside the learners' heads and better understand why they are resistant or seem unable to grasp basic concepts such as natural selection, random variation, and speciation. We will also report on how the most current research is working to develop more effective tools and curricula in the future. In this study, the researchers explored key ideas associated with teaching for understanding, including the notion of conceptual change, the pivotal role of alternative conceptions, and practical implications these ideas have for teachers of science at all levels in designing learning experiences for students.

Hoz, Bowman and Kozminsky (2001) studied the occurrence and nature of learning in a university first year Introduction to Geomorphology course, and its relations with prior knowledge taught in a prerequisite course, and with the prior knowledge in the concept to be learned. Ten dimensions of knowledge were tapped before and after the course by conventional and cognitive structure measures that were derived by the concept mapping methodology. The fine-grain analysis of learning outcomes yielded the following results: (a) students acquired only a small portion of the content in the course (b) the prior geological and geomorphological knowledge did not affect the learning of the new geomorphological contents, (c) the minor effects appeared within rather than across knowledge dimensions, and they affected mainly the learning of smaller knowledge units, and (d) concept definition cannot be considered a valid probe of knowledge. The differential effects of prior knowledge question the central, global and undifferentiated role that schema theories ascribe to prior knowledge in future learning. They call for greater reference to the exposed dimensions of knowledge by suggesting additional factors to be considered in the sequencing of courses, as well as to the acquisition of complex knowledge with partial meaning of the basic knowledge units, and the use of new cognitive structure probes of knowledge.

2.3.6 Studies on Prior Knowledge and Students' Achievement

Binder, Sandmann, Sures, Theyssen and Schmiemann (2019) investigated on a study "Assessing prior knowledge types as predictors of academic achievement in the introductory phase of biology and physics study programmes using logistic regression". Students' prior knowledge is repeatedly mentioned as the best predictor of academic achievement. This study explores the relevance of these four prior knowledge types to academic achievement in the introductory phase of the two science subjects, biology and physics. The scholars assessed the knowledge types at the beginning and student achievement (measured by course completion) at the end of the first study year. Logistic regression models was applied to evaluate the relationship between the knowledge types and academic achievement. First, the researchers controlled for a well-established predictor of academic achievement in Biology and Physic. Second, they added the knowledge types as predictors. For biology, it was found that only knowledge about principles and concepts was a significant predictor in the first year. For physics, knowledge about concepts and principles as well as the ability to apply knowledge to problems was related to academic achievement. Furthermore, the results provide a profound starting point for controlled intervention studies that systematically foster the identified relevant knowledge types in each subject and aim at a theory- and empirical-based optimization of pre- and introductory courses. To predict achievement in biology courses, high school biology enrolment or biology high school grades were used as indicators for subject-specific prior knowledge in some studies. Some studies used concept inventories that are closely related to certain content areas. Therefore, in this study, the test scores are only correlated with the respective courses' grades. They found that students who took a high school course with a focus on a deep understanding of biology content performed a third of a grade better in their first introductory biology course than their peers who took a course focusing on memorising facts. Thus, in predicting biology achievement at university, it seems promising to address in which way biology content was packaged and learned by the students at high school.

Ifioma, Racheal and Ajeka (2020) investigated the effects of prior knowledge of behavioural objectives and study questions on academic performance and retention of senior secondary school students.This study sought to determine the effects of students' prior knowledge of behavioural objectives and study questions on their academic performance and retention in Biology. The study is a quasi-experimental design using 3 x 2 factorial matrix. The population of the study is 1860 SS2 students who offer Government in the eight state secondary schools in the area. The study was conducted at Government secondary school Owerri municipal council using two intact classes of 45 students each, giving a sample size of 90 students. Related literature was reviewed on three broad areas. Six research questions and six null hypotheses were formulated. The instruments used was the Government Achievement Test (GAT) and Government Retention Test (GRT). Mean and standard deviation were used to analyse the research questions while analysis of covariance was used to test the hypotheses formulated at 5% confidence level. The results revealed that providing students with a combination of behavioural objectives and study questions based on the biological concept to be taught led to better understanding of the concept and also enhanced performance and high retention of biology. Providing students with prior knowledge of behavioural objectives and study questions irrespective of their personality variables led to enhanced performance and high retention. The implications of the findings for educational practice are that teachers should make behavioural objectives and study questions available to students in written form and not only in lesson notes. Equally, the teachers should encourage students to read through the objectives and study questions before teaching commences. The study recommends that teachers should employ prior knowledge of behavioural objectives and prior knowledge of study questions to enhance their teaching. Teacher education programme packages should include training in the use of prior knowledge of behavioural objectives and study questions in Biology.

Odeyemi and Akinsola (2015) examined the effects of Mnemonics and Prior Knowledge Instructional Strategies on Students' Attitude to Mathematics. Moderating effects of Numerical Ability and Gender were also investigated. The study adopted the pretest-posttest control group, quasi experimental design with 3x2x3 factorial matrix. Two hundred and eighty-eight students from six public schools selected from three local government areas in Ibadan, Oyo State, Nigeria, participated in the study. Two instruments were developed and used: Students' Mathematics Attitudinal Scale (r=0.8) and Numerical Ability Test (r=0.77). Also used were three operational guides on Mnemonic Instructional Strategy, Prior Knowledge Instructional Strategy and Traditional Teaching Method. Four Null hypotheses were tested at 0.5 significant levels. Data collected was analysed using Analysis of Covariance, Multiple Classification Analysis (MCA) and Scheffe Post hoc test. Treatment has significant effect on students' attitude to mathematics ($F (3,284), 3.933), p<0.05$).

Students in the control group had higher attitude mean score of 71.39 than those in MIS 69.01 and PKIS 68.46. Numerical ability has no significant effect on students' attitude to mathematics ($F (3,284) = 0.15, p<0.05$), but gender has significant effect on students' attitude to mathematics. Though the control group had the highest mean score, it has been revealed that MIS and PKIS improved students' attitude to mathematics significantly. Therefore, teachers should create mnemonics that link old and new information in the students' memory, assess their knowledge at the start of instruction through examples that bridge students' prior knowledge with the new to ensure improved
performance and make teaching and learning of mathematics students-centered.

2.3.7 Studies on Mental Ability and Students' Conceptual Change

Saptono, Isnaeni and Sukaesih (2017)investigated on a descriptive study of future teacher students' mental models of essential concepts in Cell Biology using explanatory mixed-methods. Some students (n=40) of Biology Education Universitas Negeri Semarang were involved as the research subject. Instrument used include a diagnostic test, structured interview guides, and field notes to describe students' mental model. In the early stage, The researchers prepared a diagnostic test for the students performed essential concepts of Cell Biology. Students' mental models map was designed based on their answers. Furthermore, factors which affect students' mental models were identified in this study. Exploration of mental models was conducted through structured interviews with students representing each category. The interview focused on reasoning and argumentation students' abilities in answering the question on the test item. The research finding describes that students' mental model in Cell Biology is grouped into three categories, macro-mental to think based of basic content, micro-mental in correlation of content, and intuitive-mental or misconception. This finding can be used in improving research-based learning in Cell Biology.

2.3.8 Studies on Mental Ability and Students' Achievement

Bolaji, Ayanwoye, Adesina, Oyeniran and Wahab, R. A. (2016) investigated on mental ability, academic self-concept and scientific attitude as predictors of pre-service teachers' achievement in Basic General Mathematics in Oyo State, Nigeria. . Four hypotheses guided the study. An ex-post facto design was adopted for the research using two thousand 200 Level pre-service teachers selected through random sampling technique. Four research instruments were developed and validated, namely: Students Mental Ability Test (SMAT, $r = 0.83$), Students Academic Self-concept Scale (SASCS, $r = 0.79$), Students Scientific Attitude Questionnaire (SSAQ, $r = 0.81$). MRA, t-test, Analysis of Variance were used to test the set hypotheses at 0.05 level of significance. The results indicated a significant composite contribution of the predictor variables on the dependent measure ($F (3, 1996) = 19.994$; $R= 0.885$; $R2 = 0.783$; $p < 0.05$). The independent variables significantly predicted the students' attitude to Basic Mathematics with mental ability having higher predictive value ($\beta = .517$; $t = 12.266$; $p < 0.05$) followed by scientific attitude ($\beta = .381$; $t = 6.940$; $p < 0.05$) while students academic self-concept contribution had the least ($\beta = .132$; $t = 2.821$; $p < 0.05$). it was therefore recommended among others that mathematics lecturers should use eclectic teaching strategies that would increase students mental ability. Keywords: Mental ability, Scientific attitude, Academic Self-concept , Basic General Mathematics in Oyo State, Nigeria.

MeenuDev(2016) investigated on the factors affecting the academic achievement of elementary school students of NCR Delhi, India.The aim of the study was to investigate and analyze the relationship of General Mental Ability, Interest and home environment with achievement. The participants were 110 students drawn from three KendryaVidyalayas of Delhi. Their ages ranged between 13 and 14 with a mean age of 13.6 years. Two validated instruments were used to elicit responses from the participants-General mental ability test prepared by R. K Tandon (1972), Multiphasic Interest Inventory of S. K. Bawa (1998) and Home Environment Inventory of K S Mishra (1989) were adapted and administered on the selected sample. Whereas their annual examination grades of class VII were considered as academic achievement. Four major hypotheses were formulated and tested at 0.01 level of significance. Pearson-Moment Correlation Co-efficient and t-test were used to analyze the data. Findings from this study reveals that general mental ability, home environment interest and academic achievement are significantly and positively correlated.

Faremi, Akinwarere and Fakolujo(2017) examined mental ability of Junior Secondary School Students in Basic Technology in Nigeria. The study adopted survey research design. The purpose of this study is to compare the mental abilities of junior secondary school students in basic technology in terms of age, sex and types of school (Urban and Rural). Two hundred students were selected from the target population in three senatorial districts of Ondo State using multi-stage sampling technique. Thirty multiple-choice objective test items were drawn from past questions in Junior Secondary School Basic Technology and administered on the selected students. One research question was raised, three hypotheses were formulated and tested at 0.05 alpha level. Data collected were subjected to descriptive and inferential statistics. Results of the analysis revealed that there was no significant difference between the performance of students between the age of 12-13, 14-15, and 15 years plus on basic technology multiple choice test. Also there was no significant difference between the performance of male and female students on basic technology multiple-choice test. Despite the fact that there was no significant difference between students performance in term of age, the mean value revealed that students at tender age (12-13 years) performed better than their counterparts who are older in age in basic technology multiple choice test. It was recommended among others that learning of basic technology and any other related subjects should commence from early stage of human development.

2.4 Appraisal of related literature reviewed

Literature reviewed in this sub-section show that most Biology teachers have not been approaching the teaching of the subject with dynamism, thereby having routine responses to classroom situations. Though, teachers do plan lessons, they do not take time to critically and systematically consider, analyze and evaluate the pre-planned classroom activities through reflections. Consequently, they are unable to critically evaluate the teaching delivery process necessary for conceptual change in learners which would likely result into retention and assimilation of new knowledge gained as the old, pre-existing knowledge gradually dwindles.Literature reviewed on reflective strategies have focused on learners' conceptual change in Biology and have revealed that reflective instructional strategies improved students' achievement and facilitated conceptual change in Biology. Several studies have been carried out on reflective instructional strategies among in-service and pre-service teachers.

Despite teachers' efforts to teach using reflective strategies, reports of examiners revealed that majority of learners still display poor understanding of some basic concepts in Biology which have been proved over the years to be difficult for learners to comprehend as shown in their yearly poor performances in school certificate examinations in Biology. Literature reviewed revealed that reflective instructional strategies could facilitate high level of retention and assimilation of Biology concepts in secondary school learners. The moderating effects of prior knowledge and mental ability on learners' conceptual change and achievement in Biology were also considered. Literature revealed that learners come into Biology classes with invalid and unscientific prior knowledge which results in misconceptions of biological concepts. Moreover, poor display of learners' mental ability as a result of inability to reason and reflect adequately on their existing knowledge have major contribution to learners' low achievement in Biology. Therefore, this study examined reflective inquiry and explicit-reflective instructional strategies, learners' conceptual change and achievement in Biology in secondary schools in Abeokuta, Ogun State, Nigeria.

CHAPTER THREE

METHODOLODY

This chapter discusses the methodology employed in this study. The major aspects covered under the methodologyinclude the research design, variables of the study, selection of participants, instruments for data collection, validity and reliability of instruments, research procedure, data collection and statistical tools for data analysis.

3.1 Research design

This study adopted the pretest-posttest control group, quasi-experimental delayed test design. The schematic representation of the research design is as follows:

Q_1	X_1	Q_4	(E_1)
Q_2	X_2	Q_5	(E_2)
Q_3	X_3	Q_6	(C)

Where Q_1, Q_2 and Q_3 represented pretests for the experimental groups 1 and 2 and the control group respectively. Q_4, Q_5 and Q_6 represented the posttest for the experimental groups 1 and 2 and the control group respectively.

X_1 represented intervention for experimental group 1 involving reflective Inquiry strategy (RIS).

X_2 represented intervention for experimental group 2 involving explicit-reflective strategy (ERS).

X_3 represented control group involving conventional strategy (CS).

The study employed a 3 x2 x 3 factorial matrix as presented in Table 2.

Table 2: Table of Factorial Matrix of 3 x 3 x 2

Treatment	Mental ability	Prior knowledge	
		Valid	Invalid
Reflective Inquiry Strategy (RIS)	High		
	Medium		
	Low		
Explicit Reflective Strategy (ERS)	High		
	Medium		
	Low		
Conventional Strategy (CS)	High		
	Medium		
	Low		

3.2 Variables of the study

3.2.1 Independent variable: Instructional strategy manipulated at 3 levels

i. Reflective inquiry strategy

ii. Explicit- reflective strategy

iii. Conventional strategy

3.2.2 Moderator variables:

Students' priorknowledgeat two levels.

i Valid

ii Invalid

Students' mental ability at three levels:

i High

ii Medium

iii Low

3.2.3 Dependent variables

i Students' conceptual change in Biology

ii Students' achievement in Biology.

3.3 Selection of participants

This study employed a multi-stage sampling technique. Two Local Government areas (LGAs) in Abeokuta metropolis, out of the twenty in Ogun State were selected by simple random sampling technique. They are Abeokuta South and Abeokuta North. Target population for this study comprised allBiology students of SS II classes in the selected LGAs. Three schools were randomly selected in each of the two local government areas to make a total of six schools.One intact class of SSII science students in each of the six selected schools with a total of 280 participants for the study. Simple random sampling was done in some schools where there are more than one science classes. One intact science class was randomly assigned to represent a treatment group in the Abeokuta North and Abeokuta South local government areas respectively.The three groups are experimental group 1, experimental group 2 and control group.

3.3.1 Justification for selection of concepts

The three biological concepts (osmosis and diffusion, photosynthesis and cellular respiration) used in this study were selected because they were identified as areas in which students performed poorly in Senior School Certificate Examinations as reported yearly by examiners of WAEC and NECO; as they form the major part of the Senior School Certificate Examination (SSCE) syllabus on yearly basis. Selection of these concepts was also justified by the comments documented in the WAEC Examiners' reports (2015) and (2016):

(i) Learners' inability to conceptualize the stronger and weaker solutions which are hypotonic and hypertonic solutions in osmosis and diffusion.

(ii) Inability of learners to understand the relationship between light and dark reactions in photosynthesis.

(iii) Inability of learners to differentiate between the mechanisms of inhalation and exhalation during cellular respiration.

3.4 Research instruments

The eight instruments were used for the study:

1. Teachers' Instructional Guide for Reflective Inquiry Strategy (TIGRIS).
2. Teachers' Instructional Guide for Explicit-Reflective Strategy (TIGERS).
3. Teachers' Instructional Guide for Conventional Strategy (TIGCS).
4. Students' Biology Concepts Achievement Test (SBCAT)
5. Students' Mental Ability Test (SMAT)
6. Students' Biology Conceptual Change Assessment Scale (SBCCAS)
7. Students' Background Knowledge Probes of Biology Concepts (SBKPBC)
8. Research Assistants Evaluation Rating Scale (RAERS).

3.4.1. Teacher's Instructional Guide for Reflective Inquiry Strategy (TIGRIS)

The instrument (TIGRIS) was adapted from Tice and Pollard (2005) and Farrell (2010). This instrument contained step-to-step instructions which guided the researcher in the training of the teachers (research assistants) in the use of reflective inquiry strategy (experimental group 1) in the teaching of the three biological concepts selected for this study. TIGRIS followed the pattern of the lesson plans prepared by the researcher for teaching the three biological concepts. This instrument was used in training the research assistants for effective delivery of the biological concepts to participants (SSII science leaners) in experimental group 1 to enable them reflect and think critically on the subject matter through inquiry and collaborative work. Students in this group were asked probing questions by the teacher and they reflected upontheir prior knowledge for 5minutes before the intervention. After reflection, learners formulated hypotheses and gave answers to the teacher's guiding questions based on their prior knowledge of the biological concepts. Thereafter, learners were given a problem task by the teacher on the new concept as they worked in groups of five based on their performance in the mental ability test administered before intervention.Learners made inquiries as they asked questions among themselves and carried out experiments in each group following the procedures involved in the concepts. The teacher then introduced the new concept to learners as they proceeded on their inquiries. This further enabled the learners to generate new ideas and learn new knowledge from the experiments they carried out among themselves.

TIGRIS was subjected to content and face validityby giving copies of the instrument to some experts of Biology education for scrutiny. The corrected copies were ratified by the researcher's supervisor.

3.4.2 Teachers' Instructional Guide for Explicit-Reflective Strategy (TIGERS)

The instrument(TIGERS) was adapted from the work of Abd-El-Khalick and Lederman (2000). This instrument contained step-to-step instructions, which guided the researcher in the training of the teachers (research assistants) in the use of explicit-reflective strategy (experimental group 2) in teaching three biological concepts selected for this study. TIGERS followed the pattern of the lesson plans prepared by the researcher for teaching the three biological concepts. The trained research assistants exposedthe learners to learning new concepts in Biology by using explicit-reflective strategy. Leaners demonstrated each procedure involved in the concept as they worked in groups of five based on their performance in the mental ability test administered before intervention. Learners thereafter reflected for five minutes on the concepts learned after exposure to intervention and linked up with their prior knowledge they had earlier had about the concepts. Thereafter, the teacher explained explicitly to correct learners' misconceptions and the leaners further carried out activities to experiment based on teacher's explanation.TIGERS was subjected to content and face validityby some Biology experts who made corrections, comments and gave suggestions.

3.4.3 Teachers' Instructional Guide for Conventional Strategy (TIGCS)

TIGCS was developed by the researcher as a step-to-step instructions which guided the training of the teachers (research assistants) in the use of conventional strategy (control group)in teaching three biological concepts selected for this study. TIGCS followed the pattern of the lesson plans prepared by the researcher for teaching the three biological concepts. The trained research assistant wrote the topic on the chalkboard for the learners to see, defined the concept, gave shallow explanation of each term of the concepts, displayed a chart to learners, demonstrated to learners the processes involved in the concept taught, and asked the learners some questions.Teacher wrote some notes on the chalkboard for learners to copy in their notebooks. TIGCSwas subjected to content and face validityby some Biology experts who made corrections, comments and gave suggestions.

3.4.4. Students' Biology Concept Achievement Test (SBCAT)

Students' Biology Concept Achievement Test (SBCAT) was designed by the researcher to examine students' achievement in Biology before treatment and after exposure to teaching for the period of eight weeks. It comprised two sections, A and B. Section A comprised the demographic information such as Name of school, Local Government Area, and Group (Experimental or Control) of the learners. Section B contained twenty (20) questions with multiple-choice response lettered (a)-(d) which cut across all the Biology concepts which the learners were taught in this study. The test covered items distributed within all the six levels of cognitive domain namely, knowledge, comprehension, application, analysis, synthesis and evaluation. The selection of items and allocation of questions to the six levels of cognitive domain considered here were worked out mathematically based on the following criteria:

(i) Length of time for teaching each concept

(ii) Nature of lesson objectives stated in the lesson plan

SBCAT consists of twenty multiple-choice items with four optional responses lettered (a) to (d). The proportion of test items for each of the concepts was evenly distributed as shown in the table of specification in Table 3. 2. The questions were mixed and evenly distributed to allow diversity of learners' logical reasoning and conceptual understanding. The instrument was given to some Biology teachers for face and content validity to ensure that the instrument and the statements for learners' responses are well constructed. The questions were initially fifty (50) and were reduced to thirty (30) items after the first test, and later reduced to twenty (20) items after the second test. Discrimination indices between the ranges of 0.45 to 0.62 were obtained as the measure of difficulty level of the test items. The instrument was administered twice as pretest and posttest to thirty (30) science students who were not part of this study. The period between the two tests was two weeks. Data collected was subjected to reliability analysis using Kuder Richardson (KR20) having the test items at the same difficulty level.Reliability index of 0.86 was obtained.

Table 3.1: Table of Specification of Test Items for Biology Concept Achievement Test

Concept	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	Total
Osmosis	(1), (6), (7)		(3), (4)	(5)		(15)	7
Diffusion		(2)				(8), (9)	3
Cellular respiration	(11), (19)				(20)	(12), (18)	5
Photosynthesis	(10), (13), (16), (17)	(14)					5
Total	**9(45%)**	**2 (10%)**	**2 (10%)**	**1 (5%)**	**1 (5%)**	**5 (25%)**	**20**

Biology theory of practical comprising five questions with sub-sections was also administered to the same set of students simultaneously. The proportion of test items for each of the concepts was evenly distributed as shown in the tables of specification in Table 3.1 and 3.2. The questions were mixed and evenly distributed to allow diversity of learners' logical reasoning and conceptual understanding. The instrument was given to some Biology teachers for face and content validity to ensure that the instrument and the statements for learners' responses are well constructed. The instrument was subjected to test-retest reliability. Data collected were analysed using Pearson Product Moment Correlation (PPMC) and reliability coefficient of 0.82 was obtained.

Table 3.2: Table of Specification of Test Items for Biology Concept Achievement (Theory)

Concept	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	Total
Osmosis	5(i)	2a(ii)	5(ii), (iii), (iv)	5(iv)	5(ii), (iii), (iv)	5(ii), (v)	11
Diffusion	1(iv)	1(iv)	1(i),(ii), (iii),	1(iv)	1(i), (ii), (iii)	1(iv)	10
Cellular respiration	2a(i), 2a(ii), 2b(i), (ii)	2b(i), (ii)	2a(ii), 3a(ii), (iii)	2b(i), (ii)	2a(ii)	2a(i), 2b(i), (ii)	15
Photosynthesis	(4b)	(4a)	(4a)			(4b)	4
Total	**7 (17.5%)**	**5 (12.5%)**	**10 (25%)**	**4(10%)**	**7(17.5%)**	**7 (17.5%)**	**40**

3.4.5 Students' Mental Ability Test (SMAT)

Students' Mental Ability Test (SMAT) was adapted fromNational Talent Search Examination (NTSE). The instrument was developed in 2014 and was used in this study to test students' mental ability before their exposure to teaching for the period of eight weeks. The test was observed to have capacity in discriminating between high, medium and low ability level of participants. SMAT comprised two sections A and B. Section A comprised the demographic information about the respondent. These are Name of school, Local Government Area, Group (Experimental or Control). Section B contained twenty (20) questions with multiple-choice response lettered (a)-(d) which tested learners' ability in English vocabularies, grammar and spellings in different technical arrangements. The test items were distributed into four segments; each with instructions to follow by the learners in answering the questions.The questions were mixed and evenly distributed to allow diversity of learners' logical reasoning.

SMAT was revalidated based on age and school location by reviewing and critiquing in order to detect and modify technical errors. The test items were pre-tested on two different occasions within two weeks interval on thirty (30) students different from the participants of the study. The questions were initially fifty (50) and were reduced to thirty items after the first test. It was later reduced to twenty (20) items after the second test. The instrument (SMAT) was subjected to reliability and reliability index of 0.85 was obtained.

Total correct scores for all participants were recorded. Students were classified into high, medium and low mental ability groups based on their scores. Participants who scored 60% and above were assigned to high mental ability group, those who scored within the range of 59% to 40% were assigned to medium mental ability group, while those who scored less than 40% were in low mental ability group

3.4.6. Students' Biology Conceptual Change Assessment Scale (SBCCAS)

This instrument was adapted from Villafane *et al.,* (2010). Students' Biology Conceptual Change Assessment Scale (SBCCAS) is an instrument used in this study to measure learners' conceptual change pattern before and after teaching in this study as pre-test, post-test and delayed post-test, immediately after teaching and two weeks after teaching in a sequential order. Students' responses were then scored by the teacher by summing up individual's total score at the end of the exercise. The instrument comprised two sections A and B. Section A comprised the demographic information about the respondent, which include Name of school, Local Government Area, Group (Experimental or Control group).Section B comprised twenty (20) conceptual statements with a column for learners' responses and three columns for teacher's rating as *Correct, Incorrect* and *Not Sure* coded as 3, 2 and 1 respectively against each statement. The students were expected to give *Yes or*No as their responses in the column provided in front of each statement.

The instrument was given to some Biology teachers for face and content validity to ensure that the instrument and the statements for learners' responses are well constructed. The instrument was subjected to test-retest reliability and it was administered twice to thirty (30) science students who were not part of this study. The questions were initially fifty (50) before reliability and were reduced to thirty (30) items after the first test later reduced to twenty (20) items after the second test. Discrimination indices between the ranges of 0.41 to 0.62 were obtained as the measure of difficulty level each item of the test items. Duration of the two tests was two weeks. Data collected were subjected to Pearson Product Moment Correlation (PPMC) and reliability coefficient of 0.79 was obtained at $p \leq 0.05$ level of significance.

3.4. Students'Prior Knowledge Probes of Biology Concepts (SPKPBC)

Students'Prior Knowledge Probe of Biology Concepts (SPKPBC) was adapted from Angelo (1991). It is an instrument used in this study to measure students' prior knowledge of Biology concepts before their exposure to treatment. The instrument (SPKPBC) comprised two sections, A and B. Section A comprised students' demographic information which include Name of school, Local Government Area and Group (experimental or Control). Section B comprised fifteen (15) questions with columns for students' responses and coding information which indicated students' responses as invalid or valid, rated as 1or 2 respectively.

These questions were raised to measure students' prior knowledge through short answers which sampled students'prior knowledge of the concepts under study. The following steps were followed in the preparation and administration of SPKPBC:

Step 1: The trained research assistant in each school analyse each student's responses to each of the statements in order to identify what students had already known about the Biology concept before they are taught new knowledge, recognizing that their prior knowledge could either be invalid or valid.

Step 2: After Step 1, the students gave responses, the instrument was collected and the teacher introduced and taught the students new knowledge about the selected Biology concept. The students were allowed to reflect on their prior knowledge and link what they had known before entering class with the new knowledge gained.

Step 3: The students' responses in the SPKPBC were scored by the research assistant in each group with the following coding information: valid background knowledge and invalid background knowledge rated as 1 and 2 respectively.

The SPKPBC was given to some Biology teachers for face and content validity to ensure that the instrument and the statements for students' responses were well constructed.

3.4.8. Research Assistant Evaluation Rating Scale (RAERS)

The Research Assistant Evaluation Rating Scale (RAERS) is a rating scale designed and used by the researcher to evaluate the trained research assistants during teaching whether they followed the use of the instructional guides for teaching Biology concepts in this study effectively or otherwise. The rating scale comprised two sections A and B. Section A contained some demographic information about the research assistants requesting for the name of school, class taught, topic taught and type of group (experimental or control). Section B contained items to monitor and measure the adherence and ability of each research assistant to follow the steps identified in the guides for the two reflective strategies and the conventional strategy (TIGRIS, TIGERS and TIGCS) respectively.

This instrument was subjected to both face and content validity by some experts to ascertain whether the definition and explanation of each concept given were appropriate, and the target skills achieved. It was further given to the researcher's supervisor for scrutiny.

Work schedule

This plan of work was followed in carrying out this study:

2 weeks: Training of research assistants for the use of instructional guides to teach Biology.

1 week: Pre-test and scoring

8 weeks: Treatments

1 week: Post-test and scoring

2 weeks: Delayed post-test

Total: 14 weeks

3.5.1 Pre-experimental activities

The researcher collected a letter of introduction from the Head of Department of Science and Technology Education. Copies were issued to each principal of the six selected schools in Abeokuta North and Abeokuta South for acceptance and for cooperation by Biology teachers and students throughout the duration of data collection. The researcher solicited for the cooperation of the Biology teachers and students in SSII science classes in all the six selected schools. This was followed by training of the research assistants.

3.5.2 Training of research assistants

The Biology teachers of the science classes in the six selected schools were trained as research assistants one by one by the researcher before the commencement of the treatment. The training was on how to use the instructional guides for the strategies for teaching the concepts assigned to each group in Abeokuta North and South Local Government Area of Ogun State. There was repeated demonstration to attain mastery and corrections were made to achieve competence. Training exercise lasted for two weeks.

3.5.3 Administration of pre-test

The participants in each intact class in all the six selected groups were administered a pre-test by the research assistants in the first week before treatment, using these instruments in the following order:

i. Students'Prior Knowledge Probe in Biology (SBKPBC)

ii. Students' Biology Concept Achievement Test (SBCAT)

iii. Students' Biology Conceptual Change Assessment Scale (SBCCAS)

Students'Prior Knowledge Probe in Biology (SPKPBC) was first administered in order to measure students' prior knowledge of Biology concepts. This was followed by Students' Biology Concept Achievement Test (SBCAT) to measure students' achievement in Biology. This is important because participants' contact with achievement test may influence their prior knowledge of the subject matter. This is followed by the administration of Students' Biology Conceptual Change Assessment Scale (SBCCAS) to measure what the pattern of conceptual change of students would be during pretest, post-test and delayed post-test. Pre- test exercise lasted for one week.

3.5.4. The treatment

Below are the guidelines of activities in experimental groups 1and 2 and the control group as presented in the instructional guide for each strategy used in this study:

Guidelines for the use of TIGRIS

The following steps guided the trained research assistants (teachers) in teaching the learners using reflective inquiry strategy (Experimental Group 1):

Step 1: Learners recalled their previous knowledge as the teacher asked specific questions which guided them to reflect on their prior knowledge for 5 minutes before learning new concept.

Step 2: Learners formulated hypotheses and gave answers to teacher's guiding questions based on their prior knowledge of the Biology concept they reflected on.

Step 3: Learners were given a problem task by the teacher on the new concept as they worked in groups of five (5) based on their performance in the mental ability test administered before treatment.

Step 4: Learners made inquiries as they asked questions among themselves and carried out experiments in each group following the procedures involved in the concept.

Step 5: Teacher introduced the new concept to learners as the learners proceeded on their inquiries.

Step 6: Learners were supervised by the teacher as they generated new ideas and learned new knowledge from the experiments they carried out among themselves.

Step 7: Learners observed events that took place during experimentation and collected facts.

Step 8: Learners tested generated hypotheses and made inferences on the results

Step 9: Learnersfurther reflected on new information obtained for future learning.

Step 10: Learners communicated the experiments and results obtained to other learners who were not in the group.

Guidelines for the use of TIGERS

The following steps guided the trained teacher in teaching the learners using explicit-reflective strategy (Experimental Group 2):

Step 1: The teacher introduced new concept to be learned by the learners.

Step 2: Teacher taught and explained in details to the learners the Biology concept by using explicit-reflective strategy.

Step 3: Learners demonstrated each procedure involved in the concept as they worked in groups of five (5) based on their performance in the achievement test administered before treatment.

Step 4: Learners reflected on the concepts learned for 5 minutes after exposure to treatment and linked up with their prior knowledge they earlier had about the concepts.

Step 5: The teacher explained explicitly to correct learners' misconceptions.

Step 6: The learners further carried out activities to experiment based on teacher's explanation.

Step 7: Learners observed events that took place and gave reasons for their observations.

Step 8: Learners asked questions from the teacher about their observations made.

Step 9: The teacher further explained learners' questions based on their previous reflection for clarity.

Guidelines for the use of TIGCM

The following steps guided the trained teacher in teaching the learners using conventional strategy (Control Group):

Step 1: The teacher wrote the topic on the chalkboard for the learners to see.

Step 2: The teacher explained to learners the new concept taught in the class.

Step 3: The teacher displayed a chart on the wall for the learners to observe.

Step 4: The teacher demonstrated to learners the processes involved in each concept.

Step 5: The teacher asked the learners few questions on the concepts taught.

Step 6: Learners copied notes written by their teacher from the chalkboard.

Step 7: Teacher gave take home assignments to learners.

3.5.5 Administration of post-test

Post-test was then administered after the treatment to all learners in each group in the two local government areas using these instruments in the following order:

i Students' Background Knowledge Probes of Biology Concepts (SBKPBC)

ii Students'Biology Concept Achievement Test (SBCAT).

iii. Students'Biology Conceptual Change Assessment Scale (SBCCAS)

Students'Background Knowledge Probes of Biology Concepts (SBKPBC) was administered as post-test to determine whether learners' prior knowledge had changed from invalid to valid after their exposure to treatment. Students'BiologyConcept Achievement Test (SBCAT) was thereafter administered as post-test to determine the extent to which the treatment has affected students' achievement in Biology. Students'Biology Conceptual Change Assessment Scale (SBCCAS) was thereafter administered to measure the pattern of students' conceptual change of the Biology concept taught. Post-test lasted for one week.

3.5.6 Administration of delayed post-test

A delayed post-test was further administered after two weeks for all the groups without further exposure to treatment, with the use of Students' Biology Conceptual Change Assessment Scale (SBCCAS). This was also carried out to determine the students' conceptual change pattern in Biology from pre-test to post-test to delayed post-test after a time lag. The whole exercise of data collection lasted for fourteen (14) weeks.

3.6 Data analysis

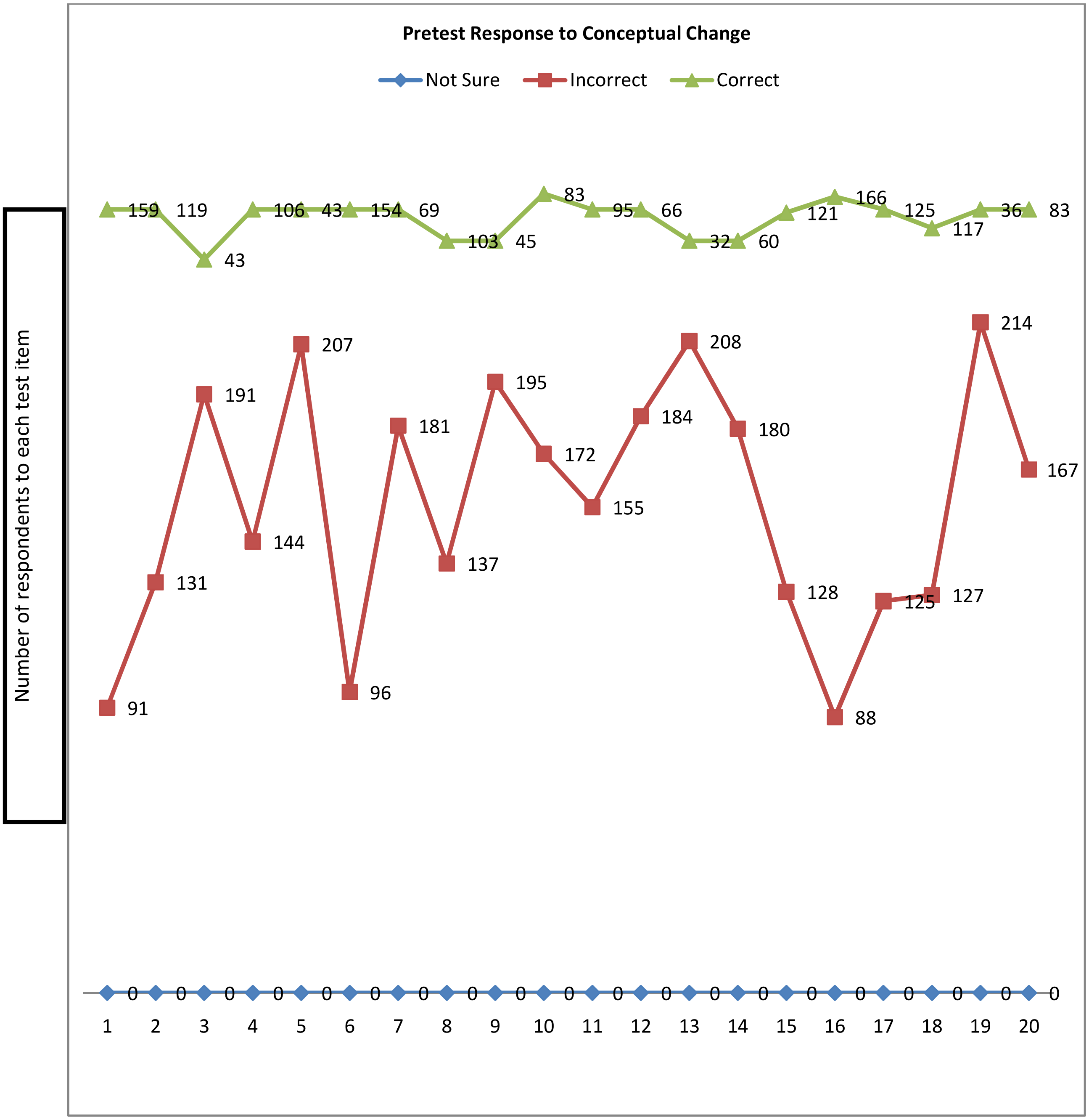
Data collected were analysed in two stages with the use of descriptive statistics of means and standard deviation, and the use of inferential statistics of Analysis of Covariance (ANCOVA) to determine the main and interaction effects of independent and moderator variables on dependent variable. Estimated Marginal Mean was used to determine the magnitude of performance of each group. Bonferonni post-hoc analysis was employed to trace the source of the observed significance among the groups. All null hypotheses were tested at $p \leq 0.05$ level of significance. Tables, graphs and figures were also used to interpret data and relevant interaction effects of variables of the study.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the analysis of data and results with respect to the research question and the sequence of the seven hypotheses tested in this study. The Analysis of Covariance (ANCOVA) was computed for the variables in both the experimental and control groups. This adjusted for the initial differences that existed in the three groups used before the treatment. Estimated Marginal Means (EMM) was also computed to discover how each group performed in the Biology post-achievement test, especially where there is a significant difference among the groups. Bonferroni pairwise comparison analysis was used in order to understand the direction of significance of the treatment across the groups. All hypotheses were tested at $p < 0.05$ level of significance. The discussion of the results is also presented.

The following are figures 4.1, 4.2 and 4.3 which represent the responses of students to pre-test, post-test and delayed post-test in the conceptual change test administered to the three treatment groups, represented by one intact science class in each of the three selected secondary schools in both Abeokuta North and Abeokuta South Local Government Areas of Ogun State.



Number of test items

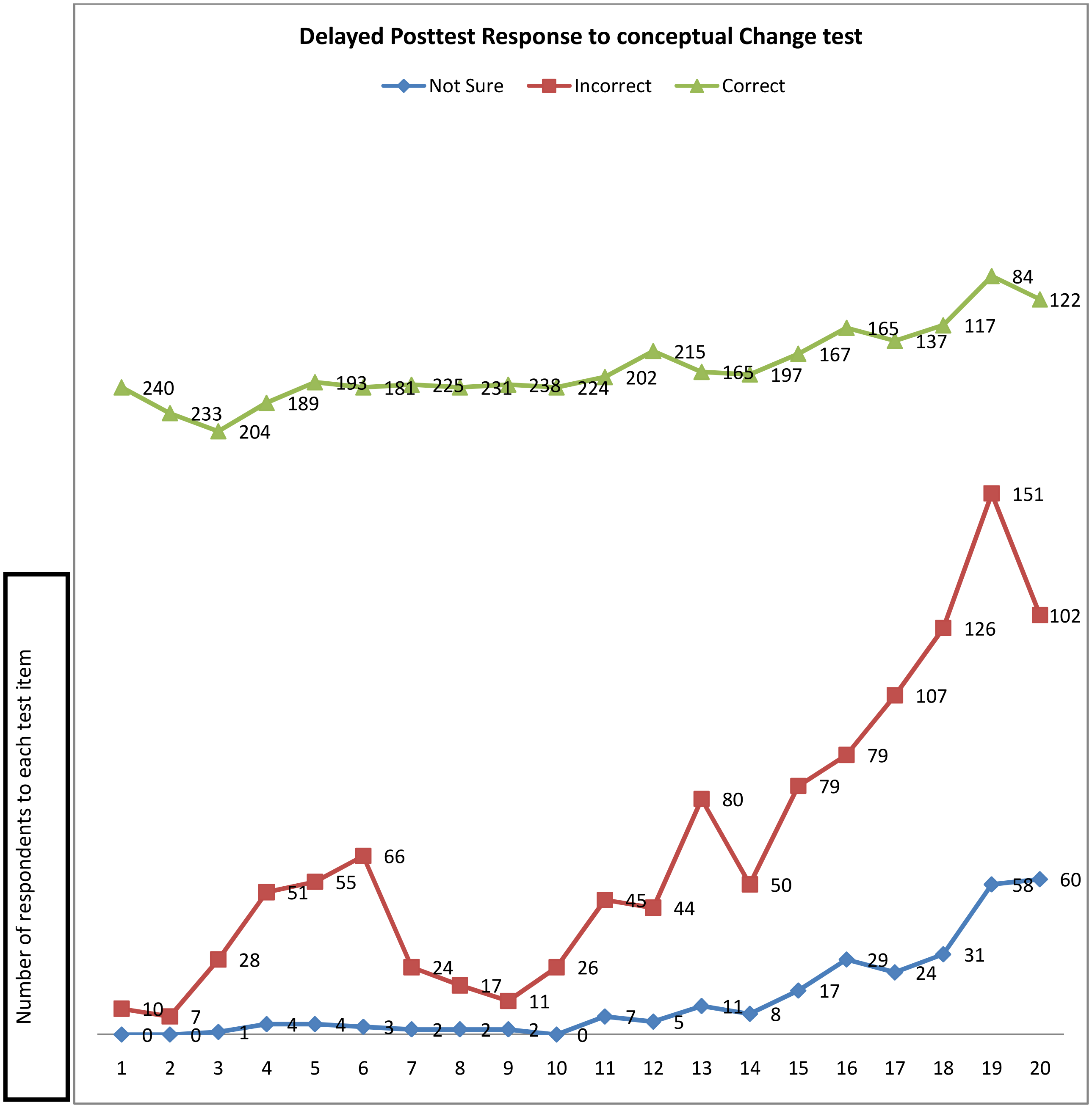
Figure 4.1: Graph of Pre-test Response to Conceptual Change

Number of respondents to each test item

Number of test items

Number of test item

Figure 4.2: Graph of Post-test Response to Conceptual Change Test



Number of test item

Figure 4.3: Graph of Delayed Post-test Response to Conceptual Change Test

Figure 4.1 reveals a decline in the correct responses of students to pre-test administered before treatment. By implication, students' prior knowledge of the biology concepts was still erroneous before they were taught new concept with the use of reflective strategies. This is in support of the finding of Abimbola (2015) and Coley (2015) that students find it difficult to understand many biological concepts due to the use of conventional strategies on the part of teachers. This eventually results in misconception of biology on the part of the students. Kurt (2013) also asserted that students come into classroom with their intuitive prior knowledge of biological concepts which could be valid or invalid compared to scientific meaning. Therefore, it is the responsibility of the subject teachers to adopt effective instructional strategies which could bring about a conceptual change in students such as reflective inquiry and explicit-reflective strategies.

Figure 4.2 shows an improvement in students' responses in the post-conceptual change test administered after treatment. The graph shows that students' correct responses increase progressively with the number of respondents to each test item. This implies that the students were gradually shifting from misconception, from fair to good understanding of biological concepts. This finding is in line with the definition of conceptual change given by Abimbola (2015) and Chi and Roscoe (2002) as a gradual shift from existing misconceptions or an intuitive way of thinking into correct conceptual understanding of scientific concepts.

Figure 4.3 reveals a clearer picture of the pattern of students' conceptual change in biology from good to better understanding of biology concepts as shown in the graph in Fig. 4.3, there is a drastic decrease in the students' choice of incorrect answers and a more progressive increase in the choice of correct answers to the test items in the delayed post-test after a time lag of two weeks. Though, there were still some students whose responses were "Not sure". This could be attributed to some interference which could have occurred as a result of time lag between the post-test and delayed post-test. Nevertheless, the students displayed a better conceptual change in their performance in delayed post-test. Hence, the pattern of conceptual change of students as described by the graphs in figures 4.1, 4.2 and 4.3 goes from fair to good and to better. By implication, treatment played a positive role in dwindling off or eroding students' misconception of biology concepts and brought a gradual restructuring of their cognitive abilities to retain new knowledge through reflection on their prior knowledge. Thus, resulting in conceptual change in biology through accommodation of new schemas as a result of students' exposure to new scientific ideas through learning of biology by inquiry and reflection. Piaget (1970) confirmed their results that conceptual change involves going through a process of accommodation in which schemas are changed when students are exposed to new information that do not fit with their original ideas. In conclusion, teachers of biology need to always identify their students' prior knowledge and allow them to reflect on their previous experiences of biology concepts before teaching them new knowledge. This would in no small measure facilitate conceptual change and enhance students' achievement in biology.

4.1.1 Research Question

What is the pattern of students' conceptual change over time in the use of Students' Prior Knowledge Probe, Students' Biology Concept Achievement Test in pre-test, post-test and onStudents' Conceptual Change Assessment Scalein delayed posttest?

Table 4.1: Table of Summary of Responses to Pre-test, Post-test & Delayed Post-test

No of Test item	Pre-test			Post –test			Delayed Post-test		
	Correct	Incorrect	Not sure	Correct	Incorrect	Not sure	Correct	Incorrect	Not sure
1	159	91	0	217	26	7	240	10	0
2	119	131	0	169	27	3	233	7	0
3	43	191	0	130	99	11	204	28	1
4	106	144	0	104	135	8	189	51	4
5	43	207	0	142	93	8	193	55	4
6	154	96	0	122	116	12	181	66	3
7	69	181	0	189	50	9	225	24	2
8	103	137	0	225	19	6	231	17	2
9	45	195	0	230	16	4	238	11	2
10	83	172	0	205	38	8	224	26	0
11	95	155	0	168	57	22	202	45	7
12	66	184	0	182	54	20	215	44	5
13	32	208	0	104	118	25	165	80	11
14	60	180	0	165	59	25	197	50	8
15	121	128	0	144	75	21	167	79	17
16	166	88	0	151	77	22	165	79	29
17	125	125	0	116	109	25	137	107	24
18	117	127	0	96	125	28	117	126	31
19	36	214	0	82	131	35	84	151	58
20	83	167	0	138	82	30	122	102	60
TOTAL	**1825**	**3021**	**0**	**3085**	**1507**	**321**	**3729**	**1158**	**278**

Table 4.1 shows that no student indicated uncertainty (not sure) during the pre-test in all the test items. Their responses were rated either correct or incorrect in all the items. However, in the responses to the post-test and delayed post-test, there were learners who indicated that they were not sure of the answer to some of the test items. This could be due to the erroneous prior knowledge they already had before either from home or the society, which may be highly resistant to change. This finding is in line with the assertion of Fisher, Wandersee and Moody (2000) that learners' prior knowledge could be highly resistant to change and could eventually lead to misconception of biology concepts as the learners find it difficult to link their prior knowledge to the new knowledge. Coley (2015) corroborated this in his statement that learners' are unable to link what they had already known before they enter classroom to the new knowledge gained after instruction due to their erroneous beliefs and misconceptions. By and large, as the learners were exposed to series of teaching of biology concepts using the two modes of reflective instructional strategies, they gradually improved and had understanding of the demands of the task in each of the items.

Hence, many of them no longer rely on guessing to provide answers during the post-test and the delayed post-test. For instance, as shown in Figure 4.1 during the pre-test, 131 students chose the incorrect answer to the item 19 under the concept of *Osmosis* which states "that at osmotic equilibrium, there is equal concentration of particles on both regions which makes the solution isotonic on either sides of the semi-permeable membrane". On the other hand, during the post-test, 214 students chose correct option to the same item19. This means that 83 students were able to make better decision as a result of intervention. However, the better decision of the 83 students ranged from not sure (35) to correct answer (131). The implication of this is that students who could have chosen the wrong options were now aware of the wrong answer, but not certain of what the right is. Although they are not able to choose the right answers consistently, except for item 6 under the concept of photosynthesis which states that"carbon(iv)oxide and chlorophyll are end products of photosynthesis".

From the summary of responses shown in table 4.1, it could be observed that the numbers of incorrect answers to all the 20 test items by all the students were decreasing from 3021 to 1507 to 1158 and the numbers of correct answers were increasing progressively from 1825 to 3085 to 3729 from pre-test to post-test and to delayed post-test respectively. By implication, the students' conceptual understanding had increased as they were allowed to reflect on their prior knowledge of the biology concept before and after they learned new knowledge and the students were able to link the previous knowledge with the new knowledge and this brought about a conceptual change in the students. This finding corroborates the position of Kareem (2014) and Ige and Kareem (2012) that in order to make the teaching and learning of biology exciting and relevant, it is important that teachers adopt relevant instructional strategies, which enable students to learn biology by reflecting on what they had already known before they enter the classroom. The definition of prior knowledge given Abimbola(2015) and Burgoon, Heddle and Duran(2010) as what the learners had already known before having an encounter with new knowledge or learning experience is also in conconance with this finding. It is the researcher's opinion that students' prior knowledge of Biology concepts should be thoroughly identified by the teacher before exposing the learners to new instructional experience.

It has been noted that most Biology teachers still prefer to use conventional method to teach biological concepts (Yahaya, 2012). This method does not provide students with relevant classroom experience, though the interaction with a rich learning environment could help them have a gradual shift from misconception. David Kolb (1976) in his theory of experiential learning gave a helpful model of successful learning in science. This is called the Kolb's Experiential Learning Cycle. The cycle contains four unique phases of learning which are concrete experience, reflective observation, abstract conceptualization and active experimentation. The learning cycle prescribes that it is not sufficient to have inclusion to learn. It is moreover imperative to consider the experience to make theories and figure thoughts which would then have the option to be associated with new conditions (Kolb, 1976). The researcher, therefore, holds the submission that the use of instructional strategies, which do not support students' conceptual change, could lead to under-achievement in Biology among secondary school students.

Testing of Null Hypotheses and Discussion

Ho1a:

There is no significant main effect of treatment on learners' conceptual change in Biology

Table 4.2: Summary of Analysis of Covariance (ANCOVA) of Post-Conceptual Change by Treatment, Prior knowledge and Mental ability

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	971.262[a]	17	57.133	14.962	0.000	0.513
Intercept	1799.054	1	1799.054	471.133	0.000	0.662
Pretest	384.408	1	384.408	100.668	0.000	0.295
Treatment	166.809	2	83.404	21.842	0.000*	0.153
Prior Knowledge	1.499	1	1.499	0.392	0.532	0.002
Mental ability	7.987	2	3.994	1.046	0.353	0.009
treatment x Prior Knowledge	0.130	2	0.065	0.017	0.983	0.000
treatment x mental ability	12.367	4	3.092	0.810	0.520	0.013
Prior Knowledge x mental ability	1.303	2	0.651	0.171	0.843	0.001
treatment x Prior Knowledge x mental ability	0.719	3	0.240	.063	0.979	0.001
Error	920.275	241	3.819			
Total	59151.000	259				
Corrected Total	1891.537	258				

$R^2 = 0.513$ (Adjusted $R^2 = 0.479$) * denotes significant at $p \leq 0.05$

Table 4.2 reveals that there is a significant main effect of treatment on students' conceptual change in Biology($F_{(2,241)}$ = 21.84; $p \leq 0.05$, partial η^2 = 0.15). Table 4.2 reveals an Adjusted R Squared of 0.48, which indicates that 48.0% of the total variation in students' conceptual change in Biology is due to the treatment, while the treatment effect size is 15.0%. This indicates that 15.0% of the variance in students' conceptual change in Biology is accounted for by the treatment. By implication, the use of reflective inquiry and explicit reflective instructional strategies by the teachers brought about a shift from misconception to conceptual understanding of biology concepts in the students. Therefore, hypothesis 1a was rejected. The significant main effect of treatment on students' conceptual change pattern could be attributed to the fact that reflective inquiry and explicit- reflective instructional strategies had been verified by previous scholars as teaching and learning strategies which stimulate students to use experiences to discover learning themselves through reflection on previous experiences which may lead to retention of scientific knowledge and understanding as well as acquisition of scientific skills and attitudes (Abimbola, 2015; Ige and Kareem, 2012; Akerson, Abd-El-Khalick and Lederman, 2000). Reflective inquiry and explicit- reflective instructional strategies also help learners discover how to solve scientific problems and answer questions on their own, draw conclusions, and to take responsibility for their own learning.

This is in line with the assertions of Ige and Kareem (2012) that students perform better in Biology when they are allowed to reflect on the previous experience, which is their prior knowledge before learning a new concept. Nevertheless, they could also be guided to reflect and connect their prior knowledge of biological concepts to the new knowledge gained, and discover facts through inquiry; as this will enable them to retain knowledge, thereby causing a drift from misconception to correct conceptual understanding rather than being taught using the conventional method which makes learners passive in the classroom. This statement corroborates the assertion of Abimbola (2015) that learners' poor retention of Biology is as a result of the prior knowledge that the learners already had before learning new knowledge, which had not been eroded due to use of conventional strategy where teachers only disseminate instructions to learners with no experimentation.

The findings are supported by thesubmission made by Akerson, Abd-El-Khalick and Lederman (2000) that an explicit reflective instructional strategy is relatively more effective in furthering science teachers' and students' understandings of nature of science (Biology inclusive).Furthermore, Babayemi (2014) in his study on use of explicit teaching strategy supported that it facilitates learners' conceptual change in science.This finding is in line with Kuhn's theory of conceptual Change (Kuhn, 1970). The conceptual change theory was borne out of Kuhn's theory of structure of Scientific Revolutions (Kuhn, 1970). This theory advocated that scientifi c ideas go through occasional periods of crisis, during which anomalies accumulate, an d may eventually result in a paradigm shift. So as to decide the extent of the critical primary impact crosswise over intervention gatherings, the estimated marginal means for the intervention gatherings was computed and the outcome is exhibited in Table 4.3.

Table 4.3 Estimated Marginal Means for Post-Conceptual Change by Treatment and Control Group

Treatment group	Mean	Std. Error
Reflective Inquiry Strategy (RIS)	15.79	0.26
Explicit Reflective Strategy (ERS)	15.40	0.25
Conventional Strategy (CS)	12.79	0.42

Table 4.3 reveals that students in Reflective Inquiry Strategy (RIS) experimental group 1 had the highest adjusted conceptual change mean score in Biology (15.79) followed by Explicit Reflective Strategy (ERS) experimental group 2 (15.40) and Conventional Strategy (CS) Control group (12.79). This order can be represented as RIS > ERS > CS. By implication, the reflective inquiry strategy had been proved to be more effective in the teaching of biology to facilitate students' conceptual change in the subject, followed by the use of explicit reflective strategy. The significant main effect of the treatment on students' conceptual change in biology could be as a result of the reflection the students in experimental group 1 (Reflective Inquiry Strategy) had on their prior knowledge of the biology concepts before treatment to link up with the new knowledge taught by the teacher.

The students in experimental group 2(Explicit Reflective Strategy) were also allowed to reflect on the new knowledge gained after treatment. In this regards, students in the experimental groups 1 and 2 actively participated in the lessons and carried out experiments involved in the biology concepts taught. The conventional strategy (control group) which had the lowest mean score (12.79) could not really bring about conceptual change in the learners because the students were not allowed to reflect on their prior knowledge before being exposed to new knowledge. Moreso, the conventional strategy used by the teacher in the control group was teacher-dominated. Students were very passive and had little or no participation in the lesson. This finding is in line with the submission of Yahaya (2012) that most biology teachers still prefer to use conventional method to teach biological concepts. From the point of view, it is evident that reflective inquiry strategy is more effective in facilitating students' conceptual change in biology.

This finding is in support of the statement of Shuaib and Usman (2002) in a Chinese proverb which says "what I hear, I forget, what I see, I remember, what I do, I understand". Through reflective inquiry instruction, students learn the new information by building upon their already existing knowledge which is logical, but incorrect and unscientific, then their incorrect thoughts are then reconstructed gradually until the conceptual gap is filled and the new knowledge is retained. Corroborating this statement, Kareem (2014) described reflective inquiry strategy as learning through experimentation whereby learnersare left to make their own submissions, disclosures and ends through reflective thinking and reasoning. However, reflective inquiry strategycould be deduced from the findings of this study as one that engages in all the domains of learning objectives in achieving a conceptual change in students for better achievement in biology. Trundle, Atwood and Christopher (2007) supported this notion in his statement that reflective inquiry strategy provides means by which teachers and students no longer view conceptual change as being influenced solely by cognitive factors, rather, affective, psychomotor, social and contextual factors that contribute to conceptual change.

Table 4.4: Bonferroni Post-hoc Analysis of Post-Conceptual Change by Treatment and Control Group

Treatment	Mean	RIS	ERS	CS
Reflective Inquiry Strategy (RIS)	15.79			*
Explicit Reflective Strategy (ERS)	15.40			*
Conventional Strategy (CS)	12.79	*	*	

Table 4.4 indicates that the post-conceptual change mean scores in Biology of the learnersexposed to reflective inquirystrategy was not significantly different from the post-conceptual change assessment mean scores of those exposed to the explicit reflectivestrategy, but significantly different from those exposed to the conventional strategy. The post-conceptual change mean scores of students in the explicit reflective strategy are significantly different from those in the conventional strategy. This indicates that the significant difference revealed by the ANCOVA is as a result of difference between the experimental groups (reflective inquiry and explicit reflective strategies) and the control group (conventional strategy),but not between the two experimental groups as far asstudents' post-conceptual change in Biology is concerned. By implication, the results showed that the pattern of conceptual change of students shifted positively as they reflected on their prior knowledge of the biology concepts before treatment and linked up with the new knowledge gained with the use of reflective instructional strategies. Consequently, misconception of biology gradually dwindled off and the learners improved in conceptual understanding of the subject. In support of this view, Sola and Ojo (2007) posited that inquiry method enables leaners to find the answers themselves. On the other hand, this result affirmed the fact that explicit-reflective strategy is associated with instructional approach that provides learners opportunity to break down the exercises in which they are locked in from various perspectives to delineate between their exercises and undertaking one by the other. Furthermore, to draw speculations about the space of learning, having reflected on these activities from within a framework of biological contexts. This affirmation supports the submission of Abd-El-Khalik (2001). andAbd-El-Khalick and Akerson (2002) that the use of explicit-reflective strategy have been found to enhance learners' knowledge of nature of science and provide learners with a cognitive learning outcomes as well as facilitating conceptual change in understanding of nature of science.

HO1b: There is no significant main effect of treatment on learners' achievement in Biology

Table 4.5: Summary of Analysis of Covariance (ANCOVA) of Post-Achievement by Treatment, Prior knowledge and Mental Ability

Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	19128.066[a]	17	1125.180	47.643	0.000	0.771
Intercept	445.435	1	445.435	18.861	0.000	0.073
Pre Achievement	10073.510	1	10073.510	426.537	0.000	0.639
Treatment	2622.683	2	1311.341	55.525	0.000*	0.315
Mental ability	3.936	2	1.968	0.083	0.920	0.001
Prior Knowledge	184.180	1	184.180	7.799	0.006*	0.031
treatment x mental ability	74.822	4	18.705	0.792	0.531	0.013
treatment x Prior Knowledge	59.436	2	29.718	1.258	0.286	0.010
Mental ability x Prior Knowledge	6.194	2	3.097	0.131	0.877	0.001
treatment x mental ability x Prior Knowledge	29.914	3	9.971	0.422	0.737	0.005
Error	5691.687	241	23.617			
Total	129583.000	259				
Corrected Total	24819.753	258				

$R^2 = 0.771$ (Adjusted $R^2 = 0.755$)

Table 4.5 shows that there is a significant main effect of treatment on students' achievement in Biology ($F_{(2,241)} = 55.53$; $p \leq 0.05$, partial $\eta^2 = 0.32$). Table 4.5 reveals an Adjusted R Squared of 0.76, which indicates that 76.0% of the total variation in students' post-achievement in Biology was as a result of the treatment, while the treatment effectis 32.0%. This indicates that 32.0% of the variation in students' achievement in Biology is accounted for by the treatment.The result obtained implies that the two reflective strategies used in this study were effectively utilised by the teachers and helped in the students' retention of knowledge of biology concepts; this invariably improved their performance in the biology concept achievement test and mental ability test administered to the learners before and after treatment in this study. Conventional strategy on the other hand, was not effective enough to allow the learners in the control group exercise their reasoning abilities due to the passive nature of the strategy, whereby students were not given opportunity to participate or reflect on their previous knowledge of the concepts taught before learning new knowledge. Invariably, the learners' performance in the biology concept achievement test and mental ability test was low compared to that of their counterparts in the experimental groups. Therefore, hypothesis 1b was rejected.Findings showed that post-test achievement mean scores of Biology students exposed to explicit reflective strategy is the highest (24.64) followed by those exposed to reflective inquiry (18.73) and the least are those of their counterparts in the control group (13.36). The findings showed an improvement in the performance of students in the post-achievement test of Biology concepts with treatment. This implies that explicit reflective and reflective inquiry strategies are more effective than the conventional strategy in improving students' achievement in Biology. Use of explicit-reflective instruction had been found to enhance learners' knowledge of nature of science and provide learners with a cognitive learning outcome that are more encouraging. Babayemi (2014) in his study on use of explicit teaching strategy supported notion that the strategy enhances students' learning outcomes in science. Reflective inquiry strategy also provides opportunity forlearners' interaction with the teacher and promotes learners' inductive and critical thinking for problem-solving, if adequately used in classroom instruction by science teacher, especially in Biology. This statement corroborates the assertion of Ige and Kareem (2012)that reflective inquiry instructional strategy, when used in classroom instructions by science teachers, provides extensive preparation for learners' interaction with the teacher as well as promotes inductive and critical thinking and problem-solving among learners. Kareem (2014) further supported that teachers need to teach the studentslearnerseffectiand guide them to reflect on what they know before they enter classroom and new knowledgethe use of reflective instructional strategies.

On the contrary, leaners tend to perform poorly in Biology when the teacher does not expose them to instructional strategies that could enhance their interest; all they are exposed to is the conventional instructional strategy. Orji and Ebele (2006) corroborated this statement in their finding that poor achievement in Biology could be attributed mainly, among other reasons, to ineffective instructional strategies adopted by majority of Biology teachers in teaching the subject. Ibe and Meduabum (2011) also supported that under-achievement in Biology could be attributed to failure of many Biology teachers to approach their teaching activities with dynamism thus, teaching becomes monotonous in nature. Findings reveal that reflective instructional strategies are more effective in classroom instruction in order to improve learners' achievement in Biology.

In order to determine the magnitude of the significant main effect across treatment groups, the estimated marginal means of the treatment groups was carried out and the result is presented in Table 4.6

and guide them to reflect on what they know before they enter classroom and on what they do in classroom, how and why they do it, in order to enhancestudents' achievement in Biology through the use of reflective instructional strategies.

On the contrary, learners tend to perform poorly in Biology when the teacher does not expose them to instructional strategies that could enhance their interest; all they are exposed to is the conventional instructional strategy. Orji and Ebele (2006) corroborated this statement in their finding that poor achievement in Biology could be attributed mainly, among other reasons, to ineffective instructional strategies adopted by majority of Biology teachers in teaching the subject. Ibe and Meduabum (2011) also supported that under-achievement in Biology could be attributed to failure of many Biology teachers to approach their teaching activities with dynamism thus, teaching becomes monotonous in nature. Findings reveal that reflective instructional strategies are more effective in classroom instruction in order to improve students' achievement in Biology.

Table 4.6 Estimated Marginal Means for Post-Achievement by Treatment and Control Group

Treatment	Mean	Std. Error
Reflective Inquiry Strategy (RIS)	18.73	0.66
Explicit Reflective Strategy (ERS)	24.64	0.63
Conventional Strategy (CS)	13.36	1.06

4.6 indicates that students in Explicit Reflective Strategy (ERS) experimental group 2 had the highest adjusted achievement mean score in Biology (24.64), followed by Reflective Inquiry Strategy (RIS) in experimental group 1 (18.73) and Conventional Strategy (CS) in control group (13.36). This order can be represented as ERS> RIS > CS. By implication, students taught using the explicit reflective instructional strategy could retain the knowledge of the biology concepts faster than their counterparts taught using the reflective inquiry strategy. This could be as a result of their reflection on the biology concepts after the teacher had explicitly explained in the course of the instruction. Nonetheless, the students in the reflective inquiry group performed better than their counterparts in the control group in the post-achievement test due to the fact that they were exposed to reflection on their prior knowledge of the biology concepts before the treatment. This enabled the learners to link their prior knowledge to the new concept taught. By and large, their performance in the post-achievement test improved better than those students in the control group who were taught with the use of conventional strategy. These findings can be deduced that teaching for reflection emphasizes students' autonomy and independent inquiry. Kareem (2014) corroborates this in her study that learners' need of control and competence are more likely to be met than when teacher lectures and learners remain passive. Polat (2013) affirmed that control and feelings of competence are essential for student motivation for better achievement in biology. Therefore, learners need to think critically and reflect on their previous knowledge. Polat (2013) further posited that learners base their own thoughts as they interpret information, not on what they had memorized or what they thought. Being allowed the freedom to say what the learners think rather than what they believe someone expects to hear is intellectual independence. This freedom combined with learning to defend their position based on evidence can lead to a sense of satisfaction on the part of the learners.

Table 4.7: Bonferroni Post-hoc Analysis of Post-Achievement by Treatment and Control Group

Treatment	Mean	RIS	ERS	CS
Reflective Inquiry Strategy (RIS)	18.73		*	*
Explicit Reflective Strategy (ERS)	24.64	*		*
Conventional Strategy (CS)	13.36	*	*	

Table 4.7 shows that the post-achievement in Biology of the learners exposed to the reflectiveinquirystrategy is significantly different from those exposed to explicitreflective and conventional strategies in their mean scores in Biology. The post-achievement mean score of learners taught with the reflective inquiry strategy is significantly different from their counterparts exposed to the conventional strategy. This indicates that, as regards students' post-achievement in Biology, the significant difference revealed by the ANCOVA is as a result of difference between the two experimental groups (reflective inquiry and explicit reflective strategies) and the control group (conventional strategy). By implication, students are likely to improve in their performance in biology when they are exposed to teaching using effective instructional strategies such as reflectiveinquiry and explicit reflective strategies. This implies that explicit reflective and reflective inquiry strategies are more effective than the conventional strategy in improving students' achievement in Biology. Use of explicit-reflective instruction had been found to enhance students' knowledge of nature of science and provide learners with a cognitive learning outcome that are more encouraging. Babayemi (2014) in his study on use of explicit teaching strategy supported that it enhances learners' learning outcomes in science. Reflective inquiry strategy also provides opportunity forlearners' interaction with the teacher and promotes learners' inductive and critical thinking for problem-solving, if adequately used in classroom instruction by science teacher, especially in Biology. This statement corroborates the assertion of Ige and Kareem (2012)that reflective inquiry instructional strategy, when used in classroom instructions by science teachers, provides extensive preparation for learners' interaction with the teacher as well as promotes inductive and critical thinking and problem-solving among learners. Kareem (2014) further supported that teachers need to teach the learners and guide them to reflect on what they know before they enter classroom and on what they do in classroom, how and why they do it, in order to enhancestudents' achievement in Biology through the use of reflective instructional strategies.

On the contrary, learners tend to perform poorly in Biology when the teacher does not expose them to instructional strategies that could enhance their interest; all they are exposed to is the conventional instructional strategy. Orji and Ebele (2006) corroborated this statement in their finding that poor achievement in Biology could be attributed mainly, among other reasons, to ineffective instructional strategies adopted by majority of Biology teachers in teaching the subject. Ibe and Meduabum (2011) also supported that under-achievement in Biology could be attributed to failure of many Biology teachers to approach their teaching activities with dynamism thus, teaching becomes monotonous in nature. Findings reveal that reflective instructional strategies are more effective in classroom instruction in order to improve students' achievement in Biology.

HO2a:There is no significant main effect of students' prior knowledge on students' conceptual change in Biology

Findings from the analysis of the null hypothesis (2a) showed that students' prior knowledge had no significant main effect on their conceptual change in Biology ($F_{(1,241)} = 0.39$; $p \geq 0.05$; partial $\eta^2 = 0.00$). Therefore, the null hypothesis 2a was not rejected. This indicates that students' prior knowledge has no effect on their conceptual change in Biology. This is contrary to the findings of some previous scholars who identified that prior knowledge has a significant main effect on students' conceptual change in Biology. For instance, Coley (2015) and Ige and Kareem (2012) in their findings submitted that identifying students' prior knowledge before exposing them to new knowledge helps in facilitating conceptual change in biology. Abimbola (2015) also supported this notion in his submission, learners should recognize what they know and what they do not know before learning new knowledge. Abimbola (2015) further argued that it is not enough to assess their knowledge and skills at the end of the lesson. Teachers also need to find out what they know before having encounter with new knowledge, so that they can identify more specifically the knowledge and skills the students have gained during the course of instruction.But this study came out with contrary finding that prior knowledge had no significant main effect on students' conceptual change in Biology. This could be deduced that it may not necessarily be that teachers should base learners' retention and correct understanding of biology concepts on identifying their prior knowledge before learning new knowledge alone. There could be other inherent student factors such as high intelligent quotient and reasoning ability, which could have facilitated students' conceptual change in biology in this study.

This new discovery can be supported by the Transformational learning theory of Mexirow (1997) in his stipulations that conceptual change is about changing how an individual learn, rather than changing the amount of knowledge possessed. Also, inclusion of existing cognitive, affective, interpersonal and moral knowledge and ability to reflect on their learning processes contribute to students' conceptual change. From this point of view, it could be deduced that there are other inherent factors in students which contribute to conceptual change in biology especially more than the prior knowledge. In conclusion, teachers of biology need to be more sensitive to individual differences of their students in order to identify how best each of them can retain knowledge for a better conceptual change in the subject

HO2b: There is no significant main effect of students' prior knowledge on students' achievement in Biology

Findings from the analysis of null hypothesis (2b) reveals that there is a significant main effect of students' prior knowledge on students' achievement in Biology ($F_{(1,241)} = 7.80$; $p \leq 0.05$, partial $\eta^2 = 0.03$). The effect is 3.0%. This indicates that 3.0% of the variance in students' achievement in Biology is accounted for by students' prior knowledge. This implies that identifying prior knowledge of learners before teaching them new biology concepts very important in improving their performance in the subject. The significant main effect of prior knowledge on students' achievement in biology could be as a result of the learners' exposure to reflection on their prior knowledge of the biology concepts before treatment; which could have helped larger number of the learners reasoned better and had valid prior knowledge with post-achievement mean score of 19.70 than their counterparts with invalidprior knowledge who had post-achievement mean score of 17.57 as shown in table 4.8. Thus, hypothesis 2b was rejected. These findings showed that valid group had higher scores indicating they had more correct entry knowledge and this could facilitate cognitive restructuring in the learners. The main significant effect of prior knowledge on learners' performance in the post- Biology Achievement Test could be traceable to the fact that prior knowledge is very vital and cannot be under-estimated in any learning situation, especially in Biology. Individual student enters classroom with different myths and superstitious cultural beliefs, which are naïve, erroneous and contradictory to the scientific knowledge, which need to be eroded through scientific exposure by using relevant and effective instructional strategies. This corroborates the assertion of Wabuke (2013) that Biology teachers should assess learners' prior knowledge at the start of instruction, probing for underlying assumptions and beliefs which may contradict the scientific ideas. Moreover, prior knowledge must be linked to new knowledge to bring about meaningful learning.This implies that for leaners to have adequate knowledge of biological concepts, their prior knowledge of the concepts must be valid or correct. Anderson and Schonborn (2008) corroborate these statements that changing learners' prior knowledge of concepts might involve the creation of a new ne ural network in the learners' brains and rewiring pre-existing neural circuits to accommodat e new knowledge for better performance in Biology.

To determine the magnitude of the significant main effect across the prior knowledge groups, the estimated marginal means of the treatment groups was carried out and the result is presented in Table 4.8

Table 4.8 Estimated Marginal Means for Post-Achievement by Prior Knowledge

Prior knowledge	**Mean**	**Std. Error**
Invalid	17.57	0.48
Valid	19.70	0.85

Table 4.8 reveals that valid prior knowledge learners had higher adjusted post-achievementmean score in Biology (19.70) while their counterparts with invalidprior knowledge had (17.57). This order can be represented as valid>Invalid.

Abimbola (2015) supports connecting prior knowledge to new knowledge may enhanc e ways by which learners learn scientific concepts meaningfully in Biology. Therefore, teacher needs to identify what the leaners already know, whether valid or invalid, before disseminating a new knowledge. Eberly (2015) corroborates this statement that for an individual to understand and develop new knowledge, one must utilize prior knowledge. Johnson (2015) also supports that learners need to possess the large volumes of new knowledge for them to be effective learners. Only learners who are able to accurately monitor their prior knowledge can focus their efforts on studying content not yet understood. However, learners who cannot make accurate judgment may only devote efforts to studying content already understood, while neglecting content that is not understood.

HO3a:There is no significant main effect of mental ability on students' conceptual change in Biology.

Table 4.2 indicates that there is no significant main effect of mental ability on students' conceptual change in Biology ($F_{(2,241)} = 1.05$: $p \geq 0.05$; partial $\eta^2 = 0.01$). Hence, the null hypothesis 3a was not rejected. This implies that students' mental ability had no effect on their conceptual change in Biology. By implication, students' mental ability test administered to measure their reasoning ability before treatment across groups had no significant effect on their conceptual understanding of the biology concepts learned in this study. In order word, it is possible for learners not to easily have a shift from misconception to correct conceptual understanding, irrespective of the teaching strategy used and their level of mental ability, whether low, medium or high. The non-significant main effect of mental ability on learners' conceptual change could be attributed to the fact that there could have been some interference in the way the learners reasoned and answered the questions in the mental ability test administered between the period of pre-test and post-test as a result of time lag, peer group, teacher factor or home factor. All these factors contribute in one way or the other to the way learners exercise their mental ability, thereby causing alteration in the pattern of conceptual change in them. In support of this finding, Gardner in his theory of multiple intelligenceestablished programs which may be useful to identify talented, low socio-economic status, minority children, who are not well represented in school program for the gifted. In support of this development, Douglas (2007) observed that insight was not one general factor, however a lot of autonomous components of equivalent significance. He called these elements essential mental abilities. Seven essential mental abilities were in this way recognized which include verbal perception, the capacity to comprehend word implications, verbal familiarity, or speed with verbal materials as in making rhymes, number, or number juggling capacity, memory, capacity to recollect words, letters, numbers and pictures, perceptual speed, the capacity to rapidly recognize visual subtleties and see similitudes and contrasts between envisioned destinations, inductive thinking or inferring general thoughts and principles for explicit data and spatial perception, the capacity to rationally, picture and control questions in three measurements.

Mental abilities speak to an individual's intellectual competence in various territories of skill. Some ordinary mental abilities incorporate verbal thinking, numerical thinking, spatial thinking and coherent thinking now and then, psychomotor aptitudes, for example, response time are likewise viewed as mental capacities. Numerous scientists presently accept that there is a general basic factor that clarifies most mental abilities, called "g" or general abilities. People with an abnormal state of general ability will, in general, be progressively effective throughout everyday life, including at work (Douglas, 2007). Different inquiries about the conviction that this general mental capacity is significant, however different abilities which are "s" or special abilities, for example, music, down to earth, passionate, likewise assume a key job in an individual's prosperity. Organizations, government and the military have utilized mental ability test for a considerable length of time to survey work candidates before business, accepting that individuals with an abnormal state of mental ability will perform better at work. In conclusion, general and specific abilities of an individual differ and could not be considered as sole factors for conceptual change in the classroom teaching and learning of science, especially in Biology

HO3b: There is no significant main effect of mental ability on students' achievement in Biology.

Table 4.5 indicates that there is no significant main effect of mental ability on students' achievement in Biology ($F_{(2,241)} = 0.08$; $p \geq 0.05$; partial $\eta^2 = 0.00$). Hence, the students' mental ability had no significant main effect on learners' achievement in biology. Therefore, null hypothesis Ho3b is not rejected.This implies that students' mental ability had no effect on their conceptual change in Biology.The non-significant main effect of mental ability on students' achievement in Biology is contrary to the assertion of Douglas (2007) that the ability of the students to reach the right level of understanding of concepts through treatment intervention has a link with his or her mental ability. This is also in contrast with the reports of Blessing (2014) and Babayemi (2014) in their studies that mental ability has a significant effect on achievement. Nevertheless, the non-significant main effect of mental ability on achievement in this study could be attributed to the mode of conduct of the test and the classroom environmental condition which might have one way or the other interfered with students' concentration. Aremu and Tella (2009) also supported this development that mental ability has no significant effect on achievement. By implication, students' mental ability test administered to measure their achievement before and after treatment across groups had no significant effect on their performance in the biology concepts learned in this study. In order word, it is possible for students not to easily retain knowledge and reason or comprehend biology concepts, irrespective of the teaching strategy used and their level of mental ability, whether low, medium or high. The non-significant main effect of mental ability on students' achievement could be deduced to the fact that there could have been some interference in the way the students reasoned and answered the questions in the mental ability test administered between the period of pre- achievement test and post- achievement test as a result of time lag, peer group, teacher factor or home factor. All these factors contribute in one way or the other to the way students exercise their mental ability, thereby causing poor performance in biology.

HO4a: There is no significant interaction effect of treatment and prior knowledge on students' conceptual change in Biology

Table 4.2 revealed there is no significant interaction effect of treatment and prior knowledge on students' conceptual change in Biology ($F_{(2,241)} = 0.02$: $p \geq 0.05$; partial $\eta^2 = 0.00$). Thus, the null hypothesis 4a was not rejected. This means that treatment and prior knowledge had no effect on students' conceptual change in Biology. This implies that the two mode reflective strategies and conventional strategy used in this study had no significant interaction effect on the pattern of conceptual change of students in biology across the groups in relation to their prior knowledge.

In other word, identifying students' prior knowledge whether valid or invalid before learning new knowledge and reflecting on those previous knowledge they initially had before teaching them new biology concepts might not jointly have a significant effect in facilitating students' conceptual change in biology. There could be some other determining factors inherent in the students which could gradually cause a shift from misconception to correct conceptual understanding of biology concepts. Previous studies had shown that most students find it difficult at times to understand some biology concepts; as a result, they resort to rote learning whereby they tend to memorise those concepts for them to pass examinations. By so doing, they probably would not be able to undergo reflection which could gradually cause a shift from misconception to correct conceptual understanding of biology concepts.

HO4b: There is no significant interaction effect of treatment and prior knowledge on students' achievement in Biology.

Table 4.5 indicates that there is no significant interaction effect of treatment and prior knowledge on students' achievement in Biology ($F_{(2,241)} = 1.26$; $p \geq 0.05$; partial $\eta^2 = 0.01$). Hence, the treatment and prior knowledge had no significant interaction effect on students' achievement in Biology. Therefore, hypothesis 4b was not rejected. This indicates that treatment and students' prior knowledge had no effect on their achievement in Biology.The non-significant interaction effect of treatment and prior knowledge on students' achievement in Biology is contrary to the statement of Olagunju, Adesoji, Ireogbu and Ige (2003) that for meaningful learning to take place, there must be an interaction between students' previous knowledge and the new materials to be learned. Ige and Kareem (2012) also asserted that identifying students' prior knowledge through reflection could result in a positive shift from misconception to conceptual understanding of basic scientific concepts, most especially Biology, which could bring about improvement in achievement in the subject matter. Nevertheless, prior knowledge not having interaction effect in this study could be as a result of students' misconceptions of biological concepts from home or among peer groups which had been resistant to accommodating new knowledge. This finding is in consonance with the assertions of Fisher, Wandersee and Moody (2000) that prior knowledge may be highly resistant to change and detrimental to students' achievement in Biology. However, this finding is in consonance with the assertions of Akinsola and Odeyemi (2014) that what students learn is conditioned by what they already know; what they know can be as damaging as what they do not know. One can deduce from the result of finding from this study that the use of the two modes of reflective instructional strategies and the conventional strategy used in this study had no joint significant effect on students' achievement of the biology concepts, with the students' prior knowledge whether valid or invalid, irrespective of whether or not the students reflected before or after treatment. What the students already know about the biology concepts, whether valid or invalid and whether they reflected before and after treatment across experimental groups or had no reflection as in the case of students in the control group, these factors could not jointly affect the students' performance in the post-achievement test in this study. It could be deduced by the result obtained that reflective strategy and explicit whether or not the teacher identifies the prior knowledge of the students.

HO5a:There is no significant interaction effect of treatment and mental ability on students' conceptual change in Biology

Table 4.2 reveals that treatment and mental ability had no significant interaction effect on students' conceptual change in Biology ($F_{(4,241)} = 0.81$; $p \geq 0.05$; partial $\eta^2 = 0.01$). Therefore, the null hypothesis 5a was not rejected. This means that treatment and mental ability had no effect on their conceptual change in Biology.This indicates that treatment and students' prior knowledge had no effect on their conceptual change in Biology. By implication, the use of the two modes of reflective instructional strategies and the conventional strategy used in this study had no significant effect on students' conceptual change of the biology concepts in relation to their mental ability. The levels of mental ability of students about the biology concepts and whether high, medium or low could not jointly determine their pattern of conceptual change in the post-conceptual change test administered to students in this study in relation to their reflection before and after treatment across experimental groups in this study. It could be deduced by the result obtained that reflective strategy and explicit reflective strategy can independently determine students' conceptual change in biology, irrespective of whether or not the leaners have high, medium or low mental ability.

As a matter of fact, Ige and Kareem (2012) asserted that reflective inquiry instructional strategy, when used in classroom instructions by biology teachers, provide extensive preparation for students' interaction with the teacher as well as promote inductive and critical thinking and problem-solving among students. Therefore, reflective inquiry instructionalstrategy could be used as an antidote for facilitating a conceptual change in Biology irrespective of whether or not the students have high, medium or low mental ability. Moreover, there is need for Biology teachers to be eager and willing in using inquiry-based and reflective strategies which could facilitate conceptual change in Biology as highlighted in one of the goals of teaching and learning of science by the National Research Council(2012). Ijioma and Onwukwe (2012) further corroborated this statement that teachers of young children need to support the natural curiosity of students and use culturally-based analogies to teach Biology concepts for conceptual change through reflection.

HO5b: There is no significant interaction effect of treatment and mental ability on students' achievement in Biology.

Table 4.5 shows that there is no significant interaction effect of treatment and mental ability on students' achievement in Biology ($F_{(4,241)} = 0.79$; $p \geq 0.05$; partial $\eta^2 = 0.01$). Hence, the treatment and mental ability had no significant interaction effect on students' achievement in Biology. Therefore, null hypothesis 5b is not rejected. This means that treatment and mental ability had no effect on students' achievement in Biology.This indicates that treatment and students' prior knowledge had no effect on their achievement in Biology. By implication, the use of the two modes of reflective instructional strategies and the conventional strategy used in this study had no joint significant effect on students' achievement of the biology concepts with their mental ability. In other word, the levels of cognitive ability of students about the biology concepts, whether high, medium or low the use of the two modes of reflective instructional strategies and the conventional strategy to their reflection before and after treatment across experimental and control groups in this study could not jointly determine their performance in the post-achievement test in this study. It could be deduced by the result obtained that reflective strategy and explicit reflective strategy can independently determine students' achievement in biology, irrespective of whether or not the students have high, medium or low mental ability.

Gardner's theory of multiple intelligence has established programs which may be useful to identify talented, low socio-economic status (SES), minority children, who are not well represented in the school program for the gifted. In support of this development, Douglas (2007) observed that insight was not one general factor, however a lot of autonomous components of equivalent significance. He called these elements essential mental abilities. Seven essential mental abilities were in this way recognized which include verbal perception, the capacity to comprehend word implications, verbal familiarity, or speed with verbal materials as in making rhymes, number, or number juggling capacity, memory, the capacity to recollect words, letters, numbers and pictures, perceptual speed, the capacity to rapidly recognize visual subtleties and see similitudes and contrasts between envisioned destinations, inductive thinking or inferring general thoughts and principles for explicit data and spatial perception, the capacity to rationally, picture and control questions in three measurements. Mental abilities speak to an individual's intellectual competence in various territories of skill. Some ordinary mental abilities incorporate verbal thinking, numerical thinking, spatial thinking and coherent thinking now and then, psychomotor aptitudes, for example, response time are likewise viewed as mental abilities. Numerous scientists presently accept that there is a general basic factor that clarifies most mental abilities, called "g" or general abilities. People with an abnormal state of general ability will, in general, be progressively effective throughout everyday life, including at work (Douglas, 2007). Different inquiries about the conviction that this general mental ability is significant, however different abilities which are "s" or specific abilities, for example, music, down to earth, passionate, likewise assume a key job in an individual's prosperity. Organizations, government and the military have utilized mental capacity testing for a considerable length of time to survey work candidates before business, accepting that individuals with an abnormal state of mental capacity will perform better at work. In conclusion, general and specific abilities of an individual differ and could not be considered as sole factors for conceptual change in the classroom teaching and learning of science, especially in Biology

HO6a: There is no significant interaction effect of prior knowledge and mental ability on students' conceptual change in Biology.

Table 4.2 indicates that there is no significant interaction effect of prior knowledge and mental ability on students' conceptual change in Biology ($F_{(4,241)} = 0.17$: $p \geq 0.05$; partial $\eta^2 = 0.00$). Hence, the null hypothesis 6a was not rejected. This indicates that prior knowledge and mental ability had no significant effect on learners' conceptual change in Biology.This means that what the students knew about the biology concepts before they encountered new knowledge and their levels of mental ability had no effect on learners'conceptual change in Biology. By implication,what the students knew about the biology concepts before they encountered new knowledge and the levels of mental ability of students about the biology concepts, whether high, medium or low could not jointly determine their pattern of conceptual change in the post-conceptual change assessment administered to students across groups in this study. It could be deduced by the result obtained that students' prior knowledge and mental ability had no significant interaction effect on students' pattern of conceptual change in biology, irrespective of whether or not their prior knowledge of the concepts learned was valid or invalid before learning new knowledge or the leaners have high, medium or low mental ability. The students could have had some inherent factors responsible for shifting their misconception gradually and these inherent factors could have positively facilitated their conceptual change in biology, which prior knowledge and mental ability could not have had a significant interaction effect upon. Nonetheless, the fact still remains that prior knowledge of students is still a germane factor to be considered in determining students' conceptual change in any science subject, especially biology.

HO6b: There is no significant interaction effect of learners' prior knowledge and mental ability on students' achievement in Biology.

Table 4.5 reveals that there is no significant interaction effect of prior knowledge and mental ability on students' achievement in Biology ($F_{(2,241)} = 0.13$; $p \geq 0.05$; partial $\eta^2 = 0.00$). Hence, prior knowledge and mental ability had no significant interaction effect on students'achievement in Biology. Therefore, null hypothesis 6b was not rejected. This shows that students' prior knowledge and mental ability had no effect on their achievement in Biology.This means that what the students knew about the biology concepts before they encountered new knowledge and their levels of mental ability had no effect on students'achievement in Biology. By implication,what the students knew about the biology concepts before they encountered new knowledge and the levels of mental ability of students about the biology concepts and whether high, medium or low could not determine whether they are high or low achievers in the post-achievement test administered to students across groups in this study. It could be deduced by the result obtained that students' prior knowledge and mental ability had no significant interaction effect on students' achievement in biology, irrespective of whether or not their prior knowledge of the concepts learned was valid or invalid before learning new knowledge or the students have high, medium or low mental ability. The students could have had some inherent factors responsible for the students' improvement in their performance in the subject, but prior knowledge and mental ability could not have a significant interaction effect upon. Nonetheless, the fact remains that prior knowledge of students is still a germane factor to be considered in determining students' ability to retain knowledge in the long term memory to enable them perform better in examinations in any science subject, especially biology. Likewise, students' mental ability contributes immensely to their cognitive development which could have contributed to the improvement of the students' achievement in biology.

HO7a: There is no significant interaction effect of treatment, prior knowledge and mental ability on students' conceptual change in Biology.

Table 4.2 showed that the interaction effect of treatment, prior knowledge and mental ability on students' conceptual change in Biology is not significant ($F_{(4,241)}$ = 0.06:$p \geq 0.05$; partial $\eta^2 = 0.00$). Therefore, the null hypothesis 7a was not rejected. This implies that treatment, prior knowledge and mental ability had no effect on students' conceptual change in Biology.This means that the use of the two modes reflective strategies and the conventional strategy used in this study,what the students knew about the biology concepts before they encountered new knowledge, whether valid or invalid and their levels of mental ability had no joint significant effect on students'conceptual change in Biology. By implication,the strategies the teacher used in disseminating the new knowledge, what the students knew about the biology concepts before they encountered new knowledge and the levels of mental ability of students about the biology concepts, whether high, medium or low could not jointly determine their pattern of conceptual change in the post-conceptual change assessment administered to the students across groups in this study. It could be deduced from the result obtained that treatment, students' prior knowledge and mental ability had no significant interaction effect on students' pattern of conceptual change in biology, irrespective of whether or not they were exposed to reflection before, during or after treatment, whether their prior knowledge of the concepts learned was valid or invalid before learning new knowledge or the students have high, medium or low mental ability. The students could have had some inherent factors responsible for shifting their misconception gradually and these inherent factors could have positively facilitated their conceptual change in biology, which the treatment, prior knowledge and mental ability could not have had a significant interaction effect upon. Nonetheless, the fact still remains that students need to be exposed to relevant and effective strategies such as reflective strategies with could facilitate their conceptual change in biology; prior knowledge students is still a germane factor to be considered in determining students' conceptual change in any of the science subjects, most especially biology.Therefore, reflective inquiry instructionalstrategy could be used as an antidote for facilitating a conceptual change in Biology. Moreover, there is need for Biology teachers to be eager and willing in using inquiry-based and reflective strategies which could facilitate conceptual change in Biology.In consonance with this statement, Celio, Durlak and Dymnarcki (2011) in their investigation included request exercises combined with organized reflective activities. For instance, after a movement wherein students sorted out different sorts of creatures, recognizes into various classes. Students were additionally occupied with a discovery action in which they detailed speculations and surveyed their legitimacy dependent on proof, and were then guided to acknowledge similarities between such exercises and crafted by researchers. Twenty-seven students were haphazardly met previously and at the end of the unit. Celio et al., (2011) detailed that after guidance, more students comprehended that specific thoughts and questions control request, and that experimentation to test as opposed to find the thoughts. Proof recommends that an express and reflective strategies could significantly improve students' tendency of science. This proof, be that as it may, gets from mediations embraced with science teachers. Abd-El-Khalick et al. (2000) and Akerson et al.(2000) corroborated in this manner that there is need to explore further the influence of an explicit reflective strategy for more youthful students' inclination to science. Supporting this finding, Abd-El-Khalick and Lederman(2000) in their assessment of the writing shows that an explicit reflective strategy is generally more compelling thanthe use of conventional method that does not help in assisting science teachers' understanding of nature of science.

HO7b:There is no significant interaction effect of treatment, prior knowledge and mental ability on students' achievement in Biology.

Table 4.5 indicates that there is no significant interaction effect of treatment, prior knowledge and mental ability on students' achievement in Biology ($F_{(4,241)}$ =0.42; $p \geq 0.05$; partial $\eta^2 = 0.01$). Hence, treatment, prior knowledge and mental ability had no significant interaction effect on students' achievement in Biology. Therefore, null Ho7b was not rejected. This implies that treatment, prior knowledge and mental ability had no effect on students' achievement in Biology.

This means that the use of two modes of reflective strategies and the conventional strategy used in this study, what the students knew about the biology concepts before they encountered new knowledge whether valid or invalid and their levels of mental ability had no effect on students'achievement in Biology. By implication,the strategies used in teaching the biology concepts, what the students knew about the biology concepts before they encountered new knowledge whether valid or invalid and the levels of mental ability of leaners about the biology concepts whether high, medium or low could not jointly determine whether they are high or low achievers in the post-achievement test administered to students across groups in this study. To buttress this fact, Wabuke (2013) posited that in the development of concepts in biology, students use prior knowledge to fuse importance into recently gained material. In such a manner, affects how leaners translate new data and choose what parts of this data are applicable and unimportant. In support of these views about prior knowledge. Wabuke (2013) and Angelo (1991) further opined that teachers ought to evaluate students' prior knowledge toward the beginning of guidance, testing for fundamental suspicions and convictions which may contradict the scientific ideas. As a result, students develop misconceptions which may invariably bring about poor achievement of students in Biology. However, in contrary to the findings of previous scholars, Fisher, Wandersee and Moody (2000) stated that prior knowledge may be highly resistant to change. This statement serves as evidence from the submissions of Abimbola(2015) and

Coley(2015)that students' brains are not clean slates on which words are recorded. Students carry more to the understanding of the learning circumstance. In support of this assertion, Akinsola and Odeyemi (2014) emphasized that what students understand could be adjusted by what they unquestionably know; what they know could be as hurting as what they don't have the foggiest thought. It could be deduced by the result obtained that treatment, students' prior knowledge and mental ability had no joint significant effect or interconnection on students' achievement in biology, irrespective of whether or not their prior knowledge of the concepts learned was valid or invalid before learning new knowledge or the students have high, medium or low mental ability. The leaners could have had some inherent factors responsible for the students' improvement in their performance in the subject, but treatment, prior knowledge and mental ability could not have a significant interaction effect upon. The non-significant interaction effect of treatment and mental ability on students' achievement in Biology, as established in the findings of this current study, is contrary to the view of Bamidele (2000) that mental ability is a clear case of theoretical constructs replacing functions, which are indirectly measurable through performance. Nevertheless, the non-significance interaction effect of treatment and mental ability on achievement in Biology, as reported in in this study, could be attributed to any interference which might have occurred due to time lag in the administration of the treatment. The result of finding can be deduced that the use of the two modes of reflective instructional strategies and the conventional strategy used in this study had no joint significant effect on students' achievement of the biology concepts with their mental ability. In other word, the levels of mental ability of students about the biology concepts, whether high, medium or low the use of the two modes of reflective instructional strategies and the conventional strategy to their reflection before and after treatment across experimental and control groups in this study could not jointly determine their performance in the post-achievement test in this study. It could be deduced by the result obtained that reflective strategy and explicit reflective strategy can independently determine students' achievement in biology, irrespective of whether or not the students have high, medium or low mental ability.

The non-significant interaction effect of treatment and mental ability on students' achievement in Biology is contrary to the assertion of Douglas (2007) that the ability of the students to reach the right level of understanding of concepts through treatment intervention has a link with his or her mental ability. This is also in contrast with the reports of Blessing (2014) and Babayemi (2014) in their studies that mental ability has a significant effect on achievement. Nevertheless, the non-significant interaction effect of treatment and mental ability on students' achievement in biology in this study could be attributed to the mode of conduct of the test and the classroom environmental condition which might have one way or the other interfere with students' concentration. Aremu and Tella (2009) also supported this development that mental ability has no significant effect on achievement. By implication, students' mental ability test administered to measure their achievement before and after treatment across groups had no significant effect on their performance in the biology concepts learned in this study. In order word, it is possible for students not to easily retain knowledge and reason or comprehend biology concepts, irrespective of the teaching strategy used and their level of mental ability, whether low, medium or high. The non-significant main effect of mental ability on students' achievement could be deduced to the fact that there could have been some interference in the way the students reasoned and answered the questions in the mental ability test administered between the period of pre-achievement test and post- achievement test as a result of time lag, peer group, teacher factor or home factor. All these factors contribute in one way or the other to the way students exercise their mental ability, thereby causing poor performance in biology. Nonetheless, the fact remains that leaners need to be exposed to relevant and effective strategies such as reflective strategies with could enhance their achievement in biology. Furthermore, prior knowledge of students is still a germane factor to be considered in determining their ability to retain knowledge in the long term memory to enable them perform better in examinations in any science subject, especially biology. Likewise, students' mental ability contributes immensely to their cognitive development which could have contributed to the improvement of the students' achievement in biology.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This Chapter contains the summary of the study, the conclusion and the recommendations. The study background, objectives, gap, methodology and findings are first presented. These are followed by the inferences from the study and recommendations.

5.1Summary of the Study

The study ascertained the effects of reflectiveinquiry and explicit reflective instructional strategies on students' conceptual change and achievement in biology of secondary schools leaners in Abeokuta metropolis, Ogun state, Nigeria. The study also examined the moderating effects of prior knowledge and mental ability. Kolb's theory of Experiential Learning provided the framework; while the pretest posttest delayed control group quasi-experimental design with a 3x2x3 factorial matrix was adopted. The study employed a multi-stage sampling technique. Two Local Government Areas (LGAs) in Abeokuta were randomly. Three secondary schools were randomly selected from each LGA and one intact class of Senior Secondary II biology studentsfrom each school were enlisted making a total of 280 students. Instruments used were Students' Mental Ability Test, Students' Biology Conceptual Change Assessment Scale, Students' Background Knowledge Probes of Biology Concepts and instructional guides. Data were analysed using descriptive statistics and Analysis of Covariance at 0.05 level of significance.

The study revealed that there was a significant main effect of treatment on students' conceptual change in Biology. The post-conceptual change assessment mean scores of the students in the explicit reflective was not significantly different from the post-conceptual change assessment mean scores of those in the reflective inquiry group, but significantly different from those in the control group. Students in the reflective inquiry group also had a post-conceptual change assessment mean scores that was significantly different from that of the students in the control group. Thus, treatment helped the students to have better understanding of each of the items. Hence, many of them no longer rely on guessing to provide answers during the post-test and the delayed post-test. Students in the reflective inquiry had the highestpost-test mean score of conceptual change assessment. This is followed by those in the explicit reflective and the control group was the least .Thus, the pattern of students' conceptual change shifted from a poor understanding of biological concepts in the control group to fair conceptual understanding in the explicit reflective group and a good conceptual understanding in the reflective inquiry group in the pre-test, post-test and delayed post-test respectively. This could be as a result of their reflection on the biology concepts after the teacher had explicitly explained in the course of the instruction. Nonetheless, the students in the reflective inquiry group performed better than their counterparts in the control group in the post-achievement test due to the fact that they were exposed to reflection on their prior knowledge of the biology concepts before the treatment. This enabled the students to link their prior knowledge to the new concept taught. By and large, their performance in the post-achievement test improved better than those students in the control group who were taught with the use of conventional strategy.

5.2 Conclusion

The findings from this study have revealed that both the reflective inquiry and explicit reflective instructional strategies are more effective in facilitating students' conceptual change as well as enhancing their achievement in Biology than the conventional strategy. Therefore, it can be concluded that when students are allowed to reflect on their existing prior knowledge of biological concepts before being taught new knowledge and also given opportunity to discover facts themselves through inquiry, there would be a better retention of the new knowledge, which could eventually produce a gradual shift from misconceptions to a better conceptual understanding in Biology. This would significantly solve the problem of poor performance of students in

Biology in secondary schools, especially in certificate examinations.Therefore, teachers of Biology should endeavor to make classroom teaching and learning very effective and productive by using instructional strategies such as reflective inquiry and explicit reflective instructional strategies, which have been established to possess the inherent qualities to facilitate students' conceptual change as well as enhance their achievement in Biology.

5.3 Educational implicationsof findings

The findings from this study have some educational implications which are as follows: Firstly, teachers of Biology should endeavor to make classroom teaching and learning really effective and productive by using instructional strategies such as reflective inquiry and explicit reflective instructional strategies which have been proven to facilitate students' conceptual change and enhance their achievement in Biology.Secondly, this study has clearly shown that when students are allowed to reflect on their existing prior knowledge of biological concepts before being taught new knowledge, and also given opportunity to discover facts themselves through inquiry, there would be agradual shift from misconceptions to a better conceptual understanding in Biology.In this regard, Biology teachers must strive to actively involve their students in inquiry-based learning and engage them in learning through reflection on their previous knowledge to enable them connect their prior knowledge to the new ideas learned during classroom teaching.

5.4 Recommendations

The following recommendations are made based on the findings of this study:

The use of reflective inquiry and explicit reflective strategies are recommended for learning of Biology concepts by students at the secondary school level since they had been established to be effective in bringing aboutdeeper understanding of concepts and longer retention of knowledge which could result in conceptual change as well as improveachievement of students in Biology.

Biology teachers should expose students to varieties of activities and practical experiences that can boost their mental ability and manipulative skills through inquiries such as reflective inquiry and explicit reflective strategies because this would help to increase the students' retention capacity and improve achievement in Biology.

Prior knowledge of students should be considered important by teachers in classroom teaching and learning of science generally and Biology in particular and priority should be given to it by allowing students to reflect on their pre-existing ideas of concepts in Biology and other sciences before and after instructions to enable them link the old ideas with the new knowledge. This would help in eroding a lot of misconceptions and gradually bring a shift to conceptual understanding and improvement in achievement of students in Biology and other science subjects.

5.5 Limitations to the Study

This study encountered certain limitations that could be a challenge to generalization of findings. They are as follows

The study was delimited to only two local government areas in Abeokuta in Ogun State where there are twenty (20) LGAs. Only six (6) schools and two hundred and fifty (280) SSII science students offering Biology were selected as participants both at the experimental and control groups in the study, whereas there are 7,129 senior secondary schools and over 400, 000 students across the state. Wider geographical terrain needs to be covered for extensive generalization of findings to be made.

The study took place within only one term out of the three terms comprised in the secondary school academic calendar. Large scale and extensive study beyond a term could make generalization of findings broader and more valid.

The study examined the influence of only two moderating variables which are prior knowledge and mental ability on students' conceptual change and achievement in Biology. There is probability of other variables such as specific ability students, gender, self-efficacy, learning style among others, to have enhanced the results obtained.

5.6 Contributions to knowledge

Reflective instructional strategies (reflective inquiry and explicit reflective) could be used by teachers to improve the students' conceptual change and achievement in Biology in secondary schools.

Biology teachers should be able to ask probing questions to elicit students' prior knowledge before exposing them to new knowledge. What the student knew before exposure to new knowledge contributes significantly to a meaningful learning when linked with the new experience. This reduces rote learning and encourages the students to perform better in Biology.

The results obtained from this study can be regarded as an empirical evidence for further studies in the field of Biology education to determine secondary school students' conceptual change and achievement in Biology.

5.7 Suggestions for further studies

The efficacy of reflective inquiry and explicit reflective strategies can be proved on the teaching and learning of other subjects since the findings of the study have proved it to be relevant for students at all educational levels and at all levels of mental ability.

The two mode reflective strategies used in this study can be replicated either in combination or in isolation, to cover more concepts, involve more schools and local government areas across the nation.

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APPENDIX 1A

UNIVERSITY OF IBADAN

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

TEACHER'S INSTRUCTIONAL GUIDE FOR REFLECTIVE INQUIRY STRATEGY (TIGRIS)

Guidelines for the use of TIGRIS

The following steps guided the trained research assistants (teachers) in teaching the leaners using reflective inquiry strategy (Experimental Group 1):

Step 1: Students recalled their previous knowledge as the teacher asked specific questions which guided them to reflect on their prior knowledge for 5 minutes before learning new concept.

Step 2: Students formulated hypotheses and gave answers to teachers guiding questions based on their prior knowledge of the Biology concept they reflected on.

Step 3: Students were given a problem task by the teacher on the new concept as they worked in groups of five (5) based on their performance in the mental ability test administered before treatment.

Step 4: Students made inquiries as they asked questions among themselves and carried out experiments in each group following the procedures involved in the concept.

Step 5: Teacher introduced the new concept to students as they also proceeded on their inquiries.

Step 6: Students were supervised by the teacher as they generated new ideas and learned new knowledge from the experiments they carried out among themselves.

Step 7: Students observed events that took place during experimentation and collected facts.

Step 8: Students tested generated hypotheses and made inferences on the results obtained.

Step 9: Studentsfurther reflected on new information obtained for future learning.

Step 10: Students communicated the experiments and results obtained to other leanerswho were not in the group.

APPENDIX 1B
UNIVERSITY OF IBADAN
DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION
TEACHER'S INSTRUCTIONAL GUIDE FOR EXPLICIT-REFLECTIVE STRATEGY (TIGERS)

Guidelines for the use of TIGERS

The following steps guided the trained teacher in teaching the students using explicit-reflective strategy (Experimental Group 2).

Step 1: The teacher introduced new concept to be learned by the students.

Step 2: Teacher taught and explained in details to the students the Biology concept by using explicit-reflective strategy.

Step 3: Students demonstrated each procedure involved in the concept as they worked in groups of five (5) based on their performance in the achievement test administered before treatment.

Step 4: Students reflected on the concepts learned for 5 minutes after exposure to treatment and linked up with their prior knowledge they earlier had about the concepts.

Step 5: The teacher explained explicitly to correct students' misconceptions.

Step 6: The students further carried out activities to experiment based on teacher's explanation.

Step 7: Students observed events that took place and gave reasons for their observations.

Step 8: Students asked questions from the teacher about their observations made.

Step 9: The teacher further explained students' questions based on their previous reflection for clarity.

APPENDIX 1C

UNIVERSITY OF IBADAN

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

INSTRUCTIONAL GUIDE FOR CONVENTIONAL STRATEGY (TIGCS)

Guidelines for the use of TIGCM

The following steps guided the trained teacher in teaching the students using conventional strategy (Control Group):

Step 1: The teacher wrote the topic on the chalkboard for the students to see.

Step 2: The teacher explained to students the new concept taught in each class.

Step 3: The teacher hanged a chart on the wall for the students to observe.

Step 4: The teacher demonstrated to students the processes involved in each concept.

Step 5: The teacher asked the students some questions on the concepts taught.

Step 6: Leaners copied notes written by their teacher from the chalkboard.

Step 7: Teacher gave take home assignments to students.

APPENDIX 2A

UNIVERSITY OF IBADAN

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

TEACHER'S LESSON PLAN FOR TEACHING OSMOSIS AND DIFFUSION USING REFLECTIVE INQUIRY STRATEGY IN EXPERIMENTAL GROUP 1

Teacher's lesson plan for teaching SS II students by the research assistants in experimental group 1 using reflective inquiry strategy in learning of the concepts of osmosis and diffusion is as follows:

Topic: Osmosis and diffusion

Duration: 80 minutes (2 periods)

Instructional materials: slices of peeled yam or potato, sugar or salt granules, water, water bath, food, dyes, perfume spray, beakers, pipettes, recommended Biology textbook for SS11 classes.

Objectives: At the end of the lesson, leaners should be able to:

(i) reflect on what they already know about the concepts of osmosis and diffusion

(ii) explain and demonstrate the processes of osmosis and diffusion

(iii) identify materials that can serve as semi-permeable membrane

(iv) identify soluble substances that can be used to demonstrate osmosis

(v) name gaseous substances that can undergo diffusion

(vi) explain the conditions of movement of particles when the solution becomes, hypotonic, isotonic and hypertonic during osmosis

(vii) identify the differences between osmosis and diffusion

(a) PREVIOUS KNOWLEDGE: Students have already been taught that osmosis and diffusion are the basis of many important life processes such as transport of water in plants, turgor pressure in plants, and water balance in aquatic creatures among others. The students reflected on their previous learning experience after the teacher asked them some questions to guide their reflection (5 minutes).

(b) INTRODUCTION

The teacher introduced the lesson by asking questions from the students on what they already knew about osmosis and diffusion to identify their prior knowledge of the concepts and allowed the students to reflect on their previous learning experience.

(c) CONTENT

STEP 1:

(i) The teacher asked some guiding questions about the concept from the students on what they already knew about osmosis and diffusion.

(ii) The students reflected on their previous experiences about the concepts of osmosis and diffusion.

(iii) Students gave definitions they already knew about osmosis and diffusion.

(iv) The teacher gave the correct definitions of osmosis and diffusion

STEP 2: Students demonstrated experiments on osmosis and diffusion to discover new knowledge about osmosis and diffusion.

STEP 3: Students made observations and recorded events as they were carrying out experiments on osmosis and diffusion by themselves and drew inferences based on their reflection.

STEP 4: The teacherfurther asked questions from the students to examine if actually the students have been able to link their prior knowledge of the concepts of osmosis and diffusion to the new knowledge gained through reflection and experimentation (inquiry).

(d) **SUMMARY:** The teacher summarized the practical lesson by briefly giving hints to students on how osmosis and diffusion could be demonstrated in living tissues.

(e) **EVALUATION:** The teacher asked the students the following questions based on what they were taught:

(i) describe the processes involved in osmosis and diffusion in a living tissue.

(ii) give three examples

APPENDIX 2B

PLAN FOR TEACHING PHOTOSYNTHESIS USING REFLECTIVE INQUIRY STRATEGY IN EXPERIMENTAL GROUP 1

Teacher's lesson plan for teaching SS II students by the research assistants in experimental group 1 using reflective inquiry strategy in learning of the concepts of photosynthesis is as follows:

Topic: Photosynthesis

Duration: 80 minutes (2 periods)

Instructional materials: green leaves, dark cupboard, cellophane paper, tripod stand, beaker, bunsen burner, water, water bath, iodine solution and recommended Biology textbook for SS11 classes.

Objectives: At the end of the lesson, students should be able to:

(i) answer some guiding questions about the definition of the concept of photosynthesis

which they already knew before coming to class .

(ii) reflect on what they already knew about the concepts of photosynthesis.

(iii) identify materials need to demonstrate an experiment that starch is produced during photosynthesis.

(iv) demonstratean experiment to show that starch is produced during photosynthesis.

(v) make observations and record events as they carry out the experiment on photosynthesis based on their reflection.

(vi) record events that take place during the experiment and draw inferences.

(vii) reflect on the new discoveries made during the experiment

(a) PREVIOUS KNOWLEDGE: Students have already been taught that feeding is one of the characteristics of living things which include plants and animals.The teacher has shown them in the previous lesson various types of green plants to identify the green colour of plants and what make up the green coloration of leaves. (5 minutes).

(b) INTRODUCTION

The teacher introduced the lesson by asking question on what they already know about photosynthesis to identify the students' prior knowledge of the concepts and allow them to reflect on their previous learning experiences.

(c) CONTENT

STEP 1:

(i)The teacher asked students some guiding questions on what they already know about photosynthesis.

(ii) The students reflected on their previous experiences about the concept of photosynthesis.

(iii) Students explained what they already knew about photosynthesis.

(iv) The teacher gave the correct definition of photosynthesis.

STEP 2: Students demonstrated an experiment to show that starch is produced during photosynthesis.

STEP 3: Students made observations and recorded events as they demonstrated an experiment on photosynthesis by themselves and drew inferences based on their reflection.

STEP 4: The teacherfurther asked questions from to students to examine if actually the students have been able to link their prior knowledge of the concepts of photosynthesis to the new knowledge gained through reflection and experimentation (inquiry).

(d) **SUMMARY:** The teacher summarized the practical lesson by briefly giving hints to students on how starch is produced during photosynthesis in a green leaf.

(e) **EVALUATION**

The teacher asked the students the following questions based on what they were taught:

i. Define the process of photosynthesis;

ii. Describe briefly an experiment to show that starch is produced during photosynthesis;

iii. Write a balanced equation for the process of photosynthesis.

APPENDIX 2C
UNIVERSITY OF IBADAN
DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION
TEACHER'S LESSON PLAN FOR TEACHING CELLULAR RESPIRATION USING REFLECTIVE INQUIRY STRATEGY IN EXPERIMENTAL GROUP 1

Teacher's lesson plan for teaching SS II students by the research assistants in experimental group 1 using reflective inquiry strategy in learning of the concepts of cellular respiration is as follows:

Topic: Cellular Respiration

Duration: 80 minutes (2 periods)

Instructional materials: viable bean seeds, cotton wool, beakers, petri dishes, bottles and bottle corks, calcium carbide and recommended Biology textbook for SS11 classes.

Objectives: At the end of the lesson, students should be able to:

i. answer some guiding questions about the definition of the concept of cellular respiration based on what they already know.

ii. reflect on what they already know about the concepts of cellular respiration in plants and animals by defining cellular respiration based on their prior knowledge.

iii. correctly deduce the concept of cellular respiration as the teacher explicitly explains the processes as they occur in plants and animals.

iv. demonstrate an experiment to show that respiration occurs in viable bean seeds.

(a) PREVIOUS KNOWLEDGE: Students have already been taught that all living organisms take in oxygen and release out carbon(iv) oxide during respiration. Theyhave also been taught that respiration is one of the characteristics of living things. The students reflected on their previous learning experience. (5 minutes)

(b) INTRODUCTION

The teacher will introduce the lesson by asking some guiding questions on what they already know about cellular respiration to discover their prior knowledge of the concept and they will reflect on their previous learning experience.

(c) CONTENT

STEP 1:

(i) The teacher asked students some guiding questions on what they already know about cellular respiration.

(ii) The students reflected on their previous experiences about the concepts of cellular respiration

(iii) Students gave definitions they already know about cellular respiration

(iv) The teacher gave the correct definitions of cellular respiration

STEP 2: Students made inquiries by carrying out experiments to show that respiration occurs in viable bean seeds and described the mechanisms involved in inhalation and exhalation during respiration in man.

STEP 3: Students made observations and record events as they carried out experiments on respiration by themselves and drew inferences based on their reflection.

STEP 4: The teacherfurther asked questions from the students to examine if actually the students have been able to link their prior knowledge of the concepts of cellular respiration to the new knowledge gained through reflection and experimentation (inquiry).

(d) **SUMMARY:** The teacher summarized the practical lesson by briefly giving hints

to leaners on how cellular respiration occurs in plants and animals.

(e) **EVALUATION:** The teacher asked the students the following questions based onwhat they were taught:

(i) describe an experiment to demonstrate cellular respiration in viable bean seeds.

(ii) describe the mechanisms involved in inhalation and exhalation during respiration in man.

APPENDIX 3A

UNIVERSITY OF IBADAN

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

TEACHER'S LESSON PLAN FOR TEACHING OSMOSIS AND DIFFUSION USING EXPLICIT-REFLECTIVE STRATEGYIN EXPERIMENTAL GROUP 2

Teacher's lesson plan for teaching SS II students by the research assistants in experimental group 1 using explicit- reflective strategy in learning of the concepts of osmosis and diffusion is as follows:

Topic: Osmosis and diffusion

Duration: 80 minutes (2 periods)

Instructional materials: slices of peeled yam or potato, sugar or salt granules, water, water bath, food, dyes, perfume spray, beakers, pipettes, recommended Biology textbook for SS11 classes.

Objectives: At the end of the lesson, students should be able to:

(i) define osmosis and diffusion.

(ii)describe how osmosis can be demonstrated in a living tissue.

(iii)carry out activities to demonstrate how solid and gaseous matter undergo diffusion.

(a) PREVIOUS KNOWLEDGE: Students have already been taught that osmosis and diffusion are the basis of many important life processes such as transport of water in plants, turgor pressure in plants, and water balance in aquatic creatures among others. The students reflected on their previous learning experience. (5 minutes)

(b) INTRODUCTION

The teacher introduced and explained in details the concepts of osmosis and diffusion to the students, then asked students some questions to guide their reflection.

(c) CONTENT

Step 1: Teacher introduced the new concepts of osmosis and diffusion and explained explicitly to students to prepare them for reflection on their prior knowledge of the concept.

Step 2: Teacher asked students some questions which provided opportunity for the leaners to reflect on what they already know and linked with the new knowledge the teacher have taught and explained to them about the concepts of osmosis and diffusion.

Step 3: Students engaged in activities to help them articulate their views about the concepts of osmosis and diffusion and to develop coherent conceptual understanding of the concept.

Step 4:Teacher engaged students further in a discussion and questioning to observe whether the students have actually understood the new concept taught or not.

(d) SUMMARY: The teacher summarized the lesson by briefly explaining to students the similarities and differences between osmosis and diffusion and how both of the concepts could be demonstrated.

(e) EVALUATION: The teacher asked the students the following questions based on what they were taught:

(i) describe the processes involved in osmosis and diffusion in a living tissue.

(ii) give three examples of living tissues in which osmosis can occur.

(iii) state two similarities and differences between osmosis and diffusion.

APPENDIX 3B

UNIVERSITY OF IBADAN

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

TEACHER'S LESSON PLAN FOR TEACHING PHOTOSYNTHESIS USING EXPLICIT-REFLECTIVE STRATEGYIN EXPERIMENTAL GROUP 2

Teacher's lesson plan for teaching SS II students by the research assistants in experimental group 1 using explicit- reflective strategy in learning of the concepts of photosynthesis is as follows:

Topic: Photosynthesis

Duration: 80 minutes (2 periods)

Instructional materials: green leaves, dark cupboard, cellophane paper, tripod stand, beaker, bunsen burner, water, water bath, iodine solution and recommended Biology textbook for SS11 classes.

Objectives: At the end of the lesson, students will be able to:

(i) define the term "photosynthesis".

(ii) explain how green plants manufacture their own food.

(iii) identify materials needed for experiment to produce starch during photosynthesis

(iv) demonstrate an experiment to show that starch is produced during photosynthesis.

(v) write a balanced equation for the process of photosynthesis.

(a) PREVIOUS KNOWLEDGE: Students have already been taught that feeding is one of the characteristics of living things which include plants and animals. The teacher also have shown them different green plants to show them what constitutes the green colour of plants. (5 minutes).

(b) INTRODUCTION

The teacher introduced and explained in details the concepts of photosynthesis to the students, then asked students some questions to guide their reflection.

(c) CONTENT

Step 1: Teacher introduced the new concepts of photosynthesis and explained explicitly to students to prepare them for reflection on their prior knowledge of the concept.

Step 2: Teacher asked students some questions which provided opportunity for the students to reflect on what they already knew and linked with the new knowledgethe teacher have taught and explained to them about the concepts ofphotosynthesis.

Step 3: Students engaged in activities to help them articulate their views about the concepts of photosynthesis and to develop coherent conceptual understanding of the concepts.

Step 4:Teacher engaged students further in a discussion and questioning to observe whether the leaners have actually understood the new concept taught or not.

(d) SUMMARY: The teacher summarized the practical lesson by briefly explaining to students how starch is produced during photosynthesis in a green leaf.

(e) EVALUATION: The teacher asked the students the following questions based on what they were taught:

(i) Define the process of photosynthesis

(ii) Describe briefly an experiment to show that starch is produced during photosynthesis

(i) Write a balanced equation for the process of photosynthesis

APPENDIX 3C

UNIVERSITY OF IBADAN

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

TEACHER'S LESSON PLAN FOR TEACHING CELLULAR RESPIRATION USING EXPLICIT-REFLECTIVE STRATEGYIN EXPERIMENTAL GROUP 2

Teacher's lesson plan for teaching SS II students by the research assistants in experimental group 1 using explicit- reflective strategy in learning of the concepts of cellular respiration is as follows:

Topic: Cellular respiration

Duration: 80 minutes (2 periods)

Instructional materials: viable bean seeds, cotton wool, beakers, petri dishes, bottles and bottle corks, calcium carbide and recommended Biology textbook for SS11 classes.

Objectives: At the end of the lesson, students will be able to:

(i) define cellular respiration

(ii)explain correctly how cellular respiration occurs in living organisms

(iii) carry out experiment to demonstrate cellular respiration in viable life seeds

(iv)explain the mechanisms of inhalation and exhalation in cellular respiration in man

(v) write a balanced equation for cellular respiration in living organisms

(a) PREVIOUS KNOWLEDGE: Students had been taught that all living organisms take in oxygen and release out carbon(iv) oxide during respiration. They had also been taught that respiration is one of the characteristics of living things. The students reflected on their previous learning experience. (5 minutes).

(b) INTRODUCTION

The teacher introduced and explained in details the concepts of cellular respiration to the students, then asked students some questions to guide their reflection.

(c) CONTENT

Step 1: Teacher introduced the new concepts of cellular respiration and explained explicitly to students to prepare them for reflection on their prior knowledge of the concept.

Step 2: Teacher asked students some questions which provided opportunity for the students to reflect on what they already knew and linked with the new knowledgethe teacher have taught and explained to them about the concepts of cellular respiration.

Step 3: Students engaged in activities to demonstrate how respiration occurs in viable bean seeds to help them articulate their views about the concepts of cellular respiration in plants.They also demonstrated breathing in and out to discover the mechanisms involved in inhalation and exhalation in man in order to develop coherent conceptual understanding of the concepts.

Step 4:Teacher engaged students further in a discussion and questioning to observe whether the students have actually understood the new concept taught or not.

(d) SUMMARY: The teacher summarized the practical lesson by briefly explaining to students how cellular respiration occurs in plants and animals.

(e) EVALUATION: The teacher asked the students the following questions based on what they were taught:

(i) what do you understand by the term “cellular respiration”?

(ii) describe an experiment to demonstrate cellular respiration in viable bean seeds.

(iii)explain the mechanisms of inhalation and exhalation during respiration in man.

APPENDIX 4A

UNIVERSITY OF IBADAN

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

TEACHER'S LESSON PLAN FOR TEACHING OSMOSIS AND DIFFUSION USING CONVENTIONAL STRATEGY (CONTROL GROUP)

Teacher's lesson plan for teaching SS II students by the research assistant in the control group using conventional strategy in learning of the concepts of osmosis and diffusion is as follows:

Topic: Osmosis and Diffusion

Time: 40 minutes (1 period)

Instructional materials: Charts showing the experiment to demonstrate osmosis and diffusion

Behavioural objectives: At the end of the lesson, students should be able to:

(i) Define osmosis and diffusion.

(ii) List at least three materials that can serve as semi-permeable membranes.

(iii) State any two differences between osmosis and diffusion.

Previous knowledge: Students are aware that salt or sugar can readily dissolve in water and perfume gives scent which spreads fast when sprayed.

Introduction

The teacher wrote the topic on the chalkboard and asked the studentss some questions thus:

(i) Mention two substances (solutes) that can easily dissolve in water

Name two food items that can be used as living tissues which can
allow some solutespass through them.

(ii) Name two items that can diffuse easily in air or water.

Presentation: The teacher connected the new topic with the previous topic which the students have been taught. The teacher hanged the chart on the wall for the students to observe as the teaching proceeded.

The teacher:

(i) The teacher gave definitions of osmosis and diffusion.

(ii) explained ideas and terms used in osmosis and diffusion e.g. semi-permeable membrane, hypotonic solution, isotonic solution, hypertonic solution of lower concentration region of higher concentration, osmotic equilibrium etc.

(iii) pointed at the chart to show the direction of movement of molecules form one region of concentration to another.

(iv) described the experiment shown on the chart to the students

(v) mentioned materials serve as semi-permeable membrane to demonstrate osmosis

(vi) gave examples of soluble substances that can be used to demonstrate osmosis

(vii) mentioned items that can easily spread in air or in water to explain diffusion

(viii) summarized the lesson

(ix) wrote note on the chalkboard for the students

(x) asked questions from the students

Guided practice: The students copied notes into their notebooks and monitored by the teacher as the teacher moved round the class.

EVALUATION: The teacher asked the following questions from the students :

(i) define osmosis

(ii) define diffusion

(iii) what are the differences between osmosis and diffusion?

(iv) mention two solutes that can easily dissolve in water which can be used to demonstrate osmosis.

(v) name two materials that can spread easily in air or water to demonstrate diffusion

ASSIGNMENT: Teacher gave assignment to the students to drawdiagrams to demonstrate osmosis and diffusion in their drawing books.

APPENDIX 4B

UNIVERSITY OF IBADAN

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

TEACHER'S LESSON PLAN FOR TEACHING PHOTOSYNTHESIS USING CONVENTIONAL STRATEGY (CONTROL GROUP)

Teacher's lesson plan for teaching SS II students by the research assistant in the control group using conventional strategy in learning of the concepts of photosynthesis is as follows:

Topic: Photosynthesis

Time: 40 minutes (1 period)

Instructional materials: Charts showing the experiment to demonstrate photosynthesis

Behavioural objectives: At the end of the lesson, students should be able to:

(iv) define photosynthesis

(v) state at least three conditions necessary for photosynthesis to take place.

(vi) explain how green plants produce starch during photosynthesis

Previous knowledge: Students have been taught that plants possess green pigments called chloroplasts which help to manufacture food for plants.

Introduction

The teacher wrote the topic on the chalkboard and asked the student to:

(iii) define the process of photosynthesis

(iv) mention the processes involved for starch to be produced during photosynthesis

(v) state the conditions necessary for photosynthesis to take place

Presentation: The teacher connected the new topic with the previous lesson the students have been taught. The teacher hanged the chart on the wall for the students to observe as the discussion.

The teacher:

(i) defined photosynthesis to the students.

(ii) explained how photosynthesis occur in green plants.

(iii) displayed to the class a chart showing an experiment to demonstrate that starch is produced in green plants during photosynthesis.

(iv) wrote note on the chalkboard for the students.

(iv) asked questions from the students.

Guided practice: The students copied notes into their notebooks and monitored by the teacher as he or she moved round the class.

EVALUATION: The teacher asked the following questions from the students:

(i) define photosynthesis

(ii) state the conditions necessary for the process of photosynthesis to take place

(iii) explain an experiment to show that starch is produced during photosynthesis

ASSIGNMENT: Teacher gave assignment to the students to draw diagrams to demonstrate that starch is produced during photosynthesis in their drawing books.

APPENDIX 4C

UNIVERSITY OF IBADAN

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

TEACHER'S LESSON PLAN FOR TEACHING CELLULAR RESPIRATION USINGCONVENTIONAL STRATEGY (CONTROL GROUP)

Teacher's lesson plan for teaching SS II students by the research assistant in the control group using conventional strategy in learning of the concepts of cellular respiration is as follows:

Topic: Osmosis and Diffusion

Time: 40 minutes (1 period)

Instructional materials: Charts showing the experiment to demonstrate that respiration occurs in viable bean seeds.

Behavioural objectives: At the end of the lesson, students should be able to:

(i) Define cellular respiration.

(ii) List the process of respiration in plants.

(iii) explain the mechanisms involved in inhalation and exhalation in respiration in man

Previous knowledge: Students have been taught that all living things respire by taking in oxygen and releasing carbon (iv) oxide.

INTRODUCTION

The teacher wrote the topic on the chalkboard and asked the student to:

(i) define cellular respiration

(ii) list processes involved in respiration in plants

(iii) demonstrate the process of inhalation and exhalation.

PRESENTATION: The teacher explained how respiration occurs in viable bean seeds to the students as he or she displayed a chart showing the diagram of the experiment.

The teacher:

(i) defined cellular respiration.

(ii) explained the process of respiration in plants.

(iii) explained the mechanisms of inhalation and exhalation during respiration in man.

(iv) wrote note on the chalkboard for the students.

(v) asked questions from the students.

Guided practice: The students copied notes into their notebooks and monitored by the teacher as he or she moved round the class.

EVALUATION: The teacher asked the following questions from the students:

(i) define cellular respiration.

(ii) explain the process of respiration in plants

(iii) explainthe mechanisms involved in inhalation and exhalation during respiration in man.

ASSIGNMENT: Teacher gave assignment to the students to draw diagrams to show the mechanisms involved in inhalation and exhalation during respiration in man.

APPENDIX 5A

UNIVERSITY OF IBADAN

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

STUDENTS' BIOLOGY CONCEPT ACHIEVEMENT TEST (STUBCAT)

SECTION A

PART A: DEMOGRAPHIC DATA

Name of School: ………………………………………………………………………

Local Government Area:……………………………………………………………..

Duration: 40minutes

PART B:**OBJECTIVE QUESTIONS**.

Instruction: Answer all questions. Circle the correct option that best answers each question in this section:

(1) Suppose there is a large beaker full of clear water and a drop of blue dye is added to the

Beakerof water. Eventually the water will turn a light blue colour. The process responsible for blue dye becoming evenly distributed throughout the water is:

(a) Osmosis

(b) Diffusion

(c) A reaction between water and dye.

(d) Transfusion

(2) During the process of diffusion, particles will generally move from

(a) High to low concentrations

(b) not move at all

(c) Low to high concentrations

(d) High to low concentrations through a semi-permeable membrane

(3) If two columns of water, A and B, are separated by a membrane through which only water can pass, column A contains dye and column B contains pure water. After two hours, the level of water in column A will be:

(a) Higher

(b) Lower

(c) The same height

(d) Medium

(4) If the cell of a plant that lives in fresh water was placed in a beaker containing 25% salt water solution, the central vacuole will

(a) increase in size

(b) decrease in size

(c) Remain the same size.

(d) burst

(5) Suppose you killed the plant cell mentioned in Q. 4 with poison and placed the dead cell in a 25% salt water solution. Osmosis and diffusion will

(a) Partially occur

(b) Only diffusion will continue.

(c) Only osmosis will continue.

(d) Not occur at all

(6) A semi-permeable membrane is a membrane that

(a) Selectively allows the movement of some particles and blocks the movement of others.

(b) Permits the movement of all particles.

(c) Does not permit movement of any particle.

(d) Permits movement of larger particle only

(7) Particles move from high or low concentration because

(a) They tend to move until the two areas are isotonic and they stop moving.

(b) There are too many particles crowded into one area, therefore they move to an area with more space.

(c) Particles easily get dissolved when they are in higher concentrated area.

(d) They may likely block the passage and prevent movement

(8) As the difference in concentration increases between two areas, rate of diffusion.

(a) Increases because the molecules want to spread out.

(b) Decreases because if the concentration is high enough the particles will spread less and the rate will be slowed.

(c) Becomes static because there will be no movement of molecules again.

(d) Becomes equilibrium

(9) When sugar is added to water after a very long period of time the sugar will

(a) Become solid and lumpy

(b) Sink because the sugar is heavier than the water.

(c) Dissolve easily in water.

(d) Be more concentrated on the bottom

(10) Oxygen is released from green plants during photosynthesis as

(a) An end-product

(b) A bye product

(c) A reactant.

(d) A catalyst

(11) Oxygen released during photosynthesis in green plants is made available to animals for the process of

(a) Anaerobic respiration

(b) Locomotion

(c) Growth

(d) Cellular respiration

(12) In aerobic respiration, oxygen causes the breakdown of carbohydrates (glucose) into simpler forms. This process is termed

(a) Carbolysis

(b) Glycolysis

(c) Oxidation

(d) Carboxylation

(13) Chloroplasts in green plants help during the process of photosynthesis

(a) To trap sunlight for heat.

(b) To produce green pigment in green plants

(c) To trap solar energy for food oxidation

(d) To make the plant grow tall

(14) Energy released in green plants during photosynthesis occur as

(a) Light energy

(b) Potential energy

(c) Solar energy

(d) Kinetic energy

(15) Food is stored in animal cells in

(a) Contractile vacuole

(b) Food vacuole

(c) Cell membrane

(d) Mitochondria

(16) Photosynthesis occurs

(a) Only in green plants

(b) In all plants

(c) In both plants and animals.

(d) In animals only

(17) Photosynthesis belongs to the mode of nutrition known as

(a) Heterotrophic mode of nutrition

(b) Chemosynthetic mode of nutrition.

(c) Holozoic mode of nutrition

(d) Autotrophic mode of nutrition

(18) Respiration occurs

(a) In plants only

(b) In animals only

(c) In plants and animals.

(d) In plants, animals and microorganisms

(19) One of the following is an organ of respiration in plants

(a) Lung

(b) Gill

(c) Stomata

(d) Leaf

(20) $C_6H_{12}O_6 + 6O_2 \rightleftarrows 6CO_2 + 6H_2O$ + Energy. The above equation represents a balanced equation for the process of

(a) Photosynthesis

(b) Anaerobic respiration

(c) Aerobic respiration.

(d) Hydrolysis

APPENDIX 5B

THEORY OF PRACTICAL QUESTIONS

Practical questions consist of four questions with sub-sections for the students to answer all. It avails leaners opportunity to express themselves in writing. This is to assess students' in-depth knowledge of Biology concepts.

Instruction: Answer all questions in this section.

1a. Specimen A is Potassium permanganate crystals.

Carry out the following instruction using specimen A

i. Half fill a 250 cm^3 beaker with the distilled or clean water

ii. Place the beaker of water on a flat table

iii. Using a spatula drop gently a crystal of specimen A into the beaker with water undisturbed.

iv. Observe the colour of the content in the beaker at the following intervals; immediately after dropping the crystal after 15 minutes and 30 minutes.

v. Make your recording of time (minutes) and observation/inference

2a. i Briefly explain the term respiration

ii Name the two types of respiration and write balanced equation for each of them.

b. Outline the mechanisms involved in the following processes in man

i. inhalation

ii. exhalation

3 Write the chemical equation for each processes:

i. aerobic respiration

ii. anaerobic respiration in plants

iii. anaerobic respiration in animals

4a Describe an experiment to show that green plants require sunlight for photosynthesis

b. State four conditions necessary for photosynthesis

5. Define the term Osmosis

(i) Remove the peel of an unripe pawpaw and cut into a U shape

(ii) Put some grains of salt granules inside the unripe pawpaw

(iii) Place the unripe pawpaw containing salt granules into a small Bowl half filled with clean water.

(iv)Observe the direction of flow of water in the bowl and the event that takes place in the experiment after 5 minutes. Record your observation.

(v) What Biology concept does the experiment demonstrate?

APPENDIX 6A

ANSWERS TO OBJECTIVE QUESTIONS

1.	B	11.	A
2.	A	12.	C
3.	C	13.	C
4.	A	14.	B
5.	D	15.	B
6.	A	16.	A
7.	A	17.	D
8.	B	18.	D
9.	D	19.	C
10.	B	20.	C

APPENDIX 6B

ANSWERS TO PRACTICAL QUESTIONS

(1)

S/N	Time (minutes)	Observation/inference
I	Immediately after dropping the crystal/grain	A trail/streak of purple colour Following the crystals to the bottom of beaker
II	5 (minutes) later	dissolving crystals Form a dense purple colour at the bottom of the beaker And a light layer above/top As molecules of potassium permanganate crystals move from region of high concentration to region of low concentration
III	15 (minutes) later	The whole water is covered with distinct layers purple trails still show at the middle With deep/dense purple at the bottom A light purple colour at the top And a still lighter purple colour at the top As molecules of potassium permanganate move from region of low centration
IV	30 (minutes) later	The whole medium becomes uniformly/evenly/equally purple coloured As molecules of potassium permanganate are uniformly distributed.

2a. Respiration is a process in living organisms/cell – involving enzyme-catalysed

Chemical reactions; in which food substances/glucose are broken down within cells – to release energy, in the presence or absence of oxygen

(i) aerobic respiration –

$C_6H_{12}O_6 + 6O_2$ ----> $6H_2O + 6CO_2$ ÷ Energy – Anaerobic Respiration $C_6H_{12}O_6$ --->$2C_2H_5OH$ + 2CO2 + Energy

b. (i) Inhalation

- External intercostal muscles contract; - internal intercostal muscles relax; - Ribs move up and outwards,
- Diaphragm contracts/flattens, - Volume of thorax cavity increases; - Air pressure decreases,
- Air rushes into the lungs from the atmosphere

(ii) Exhalation

- External intercostal muscles relax – internal intercostal muscles contract, - Ribs move down and inwards
- Diaphragm relaxes/becomes dome-shaped; - Volume of thorax cavity decreases, - Air pressure increases;
- Air is forced out of lungs into the atmosphere

3a(i) Aerobic respiration

$C_6 H_{12} O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + 38ATP/Energy/690kcal

(i) Anaerobic respiration in plants

$C_6 H_{12} O_6 \rightarrow 2C_2H_5OH + 2CO_2$ + 2ATP/Energy/50kcal

(ii) Anaerobic respiration in animals

$C_6 H_{12} O_6 \rightarrow 2CH_3$ OH (OH) COOH + 2ATP/Energy /150kcal

$C_6 H_{12} O_6 \rightarrow 2C_3 H_6 O_3$ + 2 ATP/Energy/150kcal

4a Experiment to show that green plants require sunlight for photosynthesis

- Take two potted plants – well watered – destarch the leaves by keeping plants in a dark cupboard
- At least for 24 hours/overnight. – Test leaf samples for both plants for starch The result is negative/yellowish brown colour shows absence of starch – leave one potted plant in the dark cupboard as a control. – Put the other plant in sunlight for 4 – 6 hours
- Re-test leaves from both plants for starch – Leaves from plant exposed to sunlight show presence of starch
- Those from the control plant/kept in dark cupboard shows absence of starch

- Indicating that sunlight is necessary for photosynthesis.

b. Other conditions necessary for photosynthesis

- Presence of water
- Carbon dioxide / carbon (IV) oxide
- Chlorophyll/Chloroplast
- Suitable temperature

5. (i) Osmosis is the movement of water molecule from the region of lower concentration to region of higher concentration of solutes through a semipermeable membrane.

(ii) – (iii) Procedure for the experiment to be carried out by the students.

(iv) Observation

- Water molecule flows from the bowl into the unripe pawpaw containing salt solutes.
- Salt solutes dissolve into a salt solution
- The two concentration region i.e. water concentration region (hypotonic) salt concentration region (hypertonic) are at osmotic equilibrium (same concentration level)
- Water levels in the two concentration regions are equal
- The experiment demonstrates the concept of osmosis.

APPENDIX 7A

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

STUDENTS' MENTAL ABILITY TEST (SMAT)

SECTION A

PART A: DEMOGRAPHIC DATA

Name of School: …………………………………………………………………

Local Government Area: ……………………………………………………………

Duration: 40minutes

SECTION B

INSTRUCTION: Answer all questions following the instructions given in each segment.

Directions for Questions1 to 5:

Arrange the given words in the sequence in which they occur in the dictionary and then choose the correct sequence from the options.

1. (A) Cloth (B) Cinema

(C) Chronic (D) Christmas

(E) Create

(1) (D), (C), (B), (A), (E)   (2) (A), (B), (C), (D), (E)

(3) (D), (B), (C), (E), (A)   (4) (D), (B), (C), (A), (E)

2. (A) Dialogue   (B) Diagram

(C) Diameter   (D) Diagnose

(E) Dial

(1) (D), (B), (E), (A), (C)   (2) (B), (D), (E), (A), (C)

(3) (A), (B), (D), (E), (C)   (4) (A), (B), (C), (D), (E)

3. (A) Navigate   (B) National

(C) Naughty   (D) Nation

(E) Narrow

(1) (E), (D), (C), (B), (A)   (2) (E), (D), (B), (C), (A)

(3) (A), (B), (C), (D), (E)   (4) (E), (B), (C), (D), (A)

4. (A) Peerless   (B) Penal

(C) Petroleum   (D) Pedestrian

(E) Pharmacy

(1) (D), (A), (B), (E), (C)   (2) (A), (B), (E), (D), (C)

(3) (D), (A), (B), (C), (E)   (4) (D), (A), (E), (C), (B)

5. (A) Unstable   (B) Unship

(C) Unsafe   (D) Unseat

(E) Unshared

(1) (A), (C), (B), (D), (E)   (2) (C), (D), (E), (B), (A)

(3) (A), (D), (E), (B), (C)   (4) (E), (D), (C), (B), (A)

Directions for Questions 6 to 10:

Select the combination of numbers so that letters arranged accordingly will form a meaningful word.

6. B L I P U S H

1 2 3 4 5 6 7

(1) 4, 5, 1, 2, 6, 3, 7 (2) 4, 5, 3, 2, 1, 6, 7

(3) 1, 2, 3, 4, 5, 6, 7 (4) 4, 5, 1, 2, 3, 6, 7

7. H L R A O C S

1 2 3 4 5 6 7

(1) 1, 2, 3, 4, 5, 6, 7 (2) 7, 6, 5, 1, 4, 2, 3

(3) 7, 6, 1, 5, 2, 4, 3 (4) 7, 6, 5, 1, 2, 4, 3

8. I K E S R T

1 2 3 4 5 6

(1) 6, 4, 5, 1, 2, 3 (2) 4, 6, 5, 1, 2, 3

(3) 6, 5, 4, 3, 2, 1 (4) 1, 2, 3, 4, 5, 6

9. M B L A L R U E

1 2 3 4 5 6 7 8

(1) 7, 1, 2, 6, 8, 3, 5, 4 (2) 1, 2, 3, 4, 5, 6, 7, 8

(3) 8, 7, 2, 1, 4, 5, 3, 6 (4) 1, 2, 3, 6, 7, 8, 4, 5

10. R G O S I E A N

1 2 3 4 5 6 7 8

(1) 3, 8, 7, 4, 5, 6, 1, 2 (2) 3, 2, 1, 5, 8, 7, 4, 6

(3) 3, 1, 2, 8, 7, 4, 5, 6 (4) 3, 1, 2, 7, 8, 5, 4, 6

Directions for Questions 11 to 16:

There are three words. The first two words to the left of (::) are related in some way. The same relationship holds between the third word to the right of sign (**::**) and one of the responses. Identify the correct related word.

11. Newspaper : Editor : : Film :?

(1) Actor (2) Producer

(3) Director (4) Story Writer

12. Calendar : Dates : : Dictionary :?

(1) Language (2) Sentences

(3) Grammar (4) Vocabulary

13. Rupee : India : : Yes :?

(1) Pakistan (2) Japan

(3) Bangladesh (4) Nepal

14. Dog : Bark : : Goat :?

(1) Bleat (2) Howl

(3) Grunt (4) Bray

15. Animals: Zoology : : Birds :?

(1) Botany (2) Philology

(3) Ornithology (4) Siesmology

Directions for Questions 16 to 20:

Choose the correct options.

16. As COUNSEL is to BITIRAK, so also GUIDANCE is to:

(1) HOHYBJBA (2) FPHZZKAB

(3) FOHYZJBB(4) OHYZKBB

17. As BLOCKED is to YOLOXPVW, so also OZFMXS is to:

(1) LABOUR(2) LAUNCH

(3) NAUGHT (4) RESULT

18. As THEREFORE is to TEEOERFRH, so also HELICOPTER is to:

(1) RETPOCILNE (2) RETPOCILEH

(3) HLCPERTOIE (4) HELICORETP

19. As RATIONAL is to RATNIOLA, so also TRIBAL is to:

(1) TRILBA (2) TIRLBA

(3) TRIALB (4) TIRLAB

20. As CIRCLE is to RICELC, so also SQUARE is to:

(1) UQSERA (2) UQSAER

(3) QUSERA (4) QSUERA

APPENDIX 7B

ANSWERS TO SMAT

(1) 1 (2) 1 (3) 2 (4) 3 (5) 2

(6) 4 (7) 3 (8) 2 (9)1 (10) 4

(11) 3 (12) 4 (13) 2 (14) 1 (15) 3

(16) 3 (17) 2 (18) 3 (19) 1 (20) 1

APPENDIX 8A

UNIVERSITY OF IBADAN

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

Students' Responses to Prior Knowledge Probe on Biology Concepts (STPKPBC)

Name of School: …………………………………………………………………

Local Government Area: ……………………………………………………………

Type of Group Taught (Experimental or Control Group)

SECTION B

Instruction: Students are expected to write the answers to each of the questions in each row in the column provided for students' responses below:

S/N	Statement	Student's responses
1	How do particles of gases move during diffusion?	
2	If two columns of water are separated by a membrane through which only water can pass, column A contains dye and column B contains pure water. After two hours, what will happen to the level of water in column A?	
3	If the cell of a plant that lives in fresh water was placed in a beaker containing 25% salt water solution, what will happen to the central vacuole?	
4	Suppose you killed the plant cell mentioned in Q. 3 with poison and placed the dead cell in a 25% salt water solution. What will happen to the cell?	
5	Define theconcept of semi-permeable membrane.	
6	When energy is released during photosynthesis in what form does it exist?	
7	In what way is osmosis different from diffusion?	
8	What do you understand by the term 'cellular respiration'?	
9	Describe the mechanisms involved in inhalation during gaseous exchange.	
10	Explain the interrelationships between photosynthesis and cellular respiration.	
11	What do you understand by the term	

	"matter"?	
12	How do particles of each of the state of matter behave under high or increased temperature?	
13	Describe the mechanism involved in exhalation during gaseous exchange.	
14	How are particles in solid state of matter arranged?	
15	Matter exists in three states. Which of the states do particles diffuse into the atmosphere when released?	

APPENDIX 8B

UNIVERSITY OF IBADAN

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

RESEARCH ASSISTANTS CODING INFORMATION ON STUDENTS' PRIOR KNOWLEDGE PROBEOF BIOLOGY CONCEPTS(SPKPBC)

SECTION A

PART A: DEMOGRAPHIC DATA

Name of School: ………………………………………………………………………

Local Government Area: ……………………………………………………………..

Type of Group Taught (Experimental or Control Group)

SECTION B

Instruction: The research assistant is expected to score and indicate students' responses given in the appropriate column as follows:

(1) = invalid background knowledge (not relevant)

(2) = valid background knowledge (correct and relevant)

Note that this probe is not a test or quiz and will not be graded. It will only be used to make effective instructional decisions.

S/N	Statement	Responses	Coding information	
			Invalid(1)	Valid(2)
1.	How do particles of liquids and gases move during osmosis and diffusion?			
2.	If two columns of water are separated by a membrane through which only water can pass, column A contains dye and column B contains pure water. After two hours, what will happen to the level of water in column A?			
3.	If the cell of a plant that lives in fresh water was placed in a beaker containing 25% salt water solution, what will happen to the central vacuole?			
4.	Suppose you killed the plant cell mentioned in Q.3 with poison and placed the dead cell in a 25% salt water solution. What will happen to the cell?			
5.	Define theconcept ofsemi-permeable membrane.			
6.	When energy is released during photosynthesis, in what form does it exist?			
7.	In what way is osmosis different from diffusion?			
8.	What do you understand by the term cellular respiration?			
9.	Describe the mechanisms involved in inhalation during gaseous exchange.			
10.	Explain the interrelationships between photosynthesis and cellular respiration.			
11.	What do you understand by the term “matter”?			
12.	How do particles of each of the state of matter behave under high or increased temperature?			
13	Describe the mechanism involved in exhalation during gaseous exchange.			
14	How are particles in solid state of matter arranged?			

15 Matter exists in three states. Which of the states do particles diffuse into the atmosphere when released?

APPENDIX 9

UNIVERSITY OF IBADAN

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

STUDENTS'BIOLOGY CONCEPTUAL CHANGE ASSESSMENT SCALE (SBCCAS)

SECTION A

PART A: DEMOGRAPHIC DATA

Name of School: ………………………………………………………………………

Local Government Area: ……………………………………………………………

Type of Group Taught (Experimental or Control Group)

SECTION B

Instruction: Tick either YES or NO in the column provided for responses for each conceptual statement below. The ratings are to be done by the researcher whether each of the student's response is correct, incorrect or not sure.

S/N	**Conceptual Statement**	**Student Response**		**Ratings**		
		Yes	**No**	**Correct**	**Incorrect**	**Not Sure**
1	Feeding in green plants is autotrophic					
2	Photosynthesis occurs only in green plants					
3	Photosynthesis can also take place in the absence of light					
4	Photosynthesis requires oxygen to occur					
5	Respiration in plants is the same process as photosynthesis					
6	Carbon(iv)oxide and chlorophyll are end products of photosynthesis					

7	Cellular respiration is the oxidation of complex carbohydra tes which causes breakdown into simpler forms	
8	Respiration in man involves two major mechanisms which are inhalation and exhalation	
9	Inhalation involves taking in of oxygen into the blood stream through the lungs	
10	During inhalation, the diaphragm is raised up and the rib cage contracts.	
11	Respiration in animal occurs the same way as in plants.	
12	Particles of gases move randomly and collide with each other as temperature increases.	
13	All particles either solids, liquids or gases, are in constant motion	
14	Rate of diffusion of liquids and gases increases with increase in temperature	
15	Diffusion is the net movement of particle as a result of concentration gradient	
16	Osmosis is the movement of particles from the region of low concentration to region of high concentration through a selectively permeable membrane.	
17	Particles move from region of	

	high concentration to region of low concentration during osmosis.	
18	Osmosis is the same as diffusion. Both are used interchangeably	
19	At osmotic equilibrium, there is equal concentration of particles on both regions which makes the solution isotonic on either sides of the semi-permeable membrane	
20	Solid particle does not dissolve, except ice block by change of state of matter.	

APPENDIX 10

UNIVERSITY OF IBADAN

DEPARTMENT OF SCIENCE AND TECHNOLOGY EDUCATION

Research Assistant Evaluation Rating Scale (RAERS)

The rating scale was used to evaluate the trained research assistants for effective use of the instructional guide. The rating scale comprised of information requesting for the name of school, class, topic, type of group (experimental or control). It is made up of items to monitor and measure teachers' knowledge and ability to following the steps identified in the guide for the two reflective strategies. Each of the research assistants was evaluated by three different assessors or raters.

Research Assistant Evaluation Rating Scale (RAERS)

Name of School:____

Type of Group taught (Experimental or Control Group)______________________

S/N	Objectives	5	4	3	2	1
1	Extent of mastery of instructional strategy taught to effect conceptual change in the students					
2	Demonstration of adequate knowledge of the content of biological concepts taught					
3	Adherence to stated objectives					
4	Coherence with steps in the instructional guide					
5	Ability to make the lesson child-centred					
6	Ability to deliver the content of the lesson note					
7	Ability to engage all the pupils in the class					
8	Adequacy of the knowledge of evaluation procedures					

Key: Excellent=5, Good = 4, Fair = 3, Poor=2, Very poor = 1

Name of School ____

Name and Signature of Rater____

APPENDIX 11

PHOTOGRAPHS SHOWING ADMINISTRATION OF PRE-TEST, POST-TEST AND DELAYED POST-TEST

APPENDIX 12

PHOTOGRAPHS SHOWING THE CONDUCT OF REFLECTIVE INQUIRY STRATEGY

(EXPERIMENTAL GROUP 1)

APPENDIX 13

PHOTOGRAPHS SHOWING THE CONDUCT OF EXPLICIT-REFLECTIVE STRATEGY

(EXPERIMENTAL GROUP 2)

APPENDIX 14

PHOTOGRAPHS SHOWING THE CONDUCT OF CONVENTIONAL STRATEGY (CONTROL GROUP)