Chapter One

Introduction

1.1 Background to the Study

Education is the key to success in all human endeavors, and the place of science education in making human lives a better one cannot be over emphasized. The secondary education is the education children receive after primary education and before the tertiary stage. It is made up of junior and senior levels. The junior level is both prevocational and academic, while the senior level is comprehensive with core-curriculum designed to broaden students' knowledge and outlook. This means that the senior level has a tripartite look – the core, vocational and non-vocational [1]. Therefore, the teaching and learning of basic science subjects like chemistry, biology, physics, mathematics and their likes is of paramount importance in preparing students to take a career in science and technology. The National Policy on Education (NPE) is the major document which guide and gear the educational activities in Nigeria. The National Policy on Education state that science and technology shall continue to be taught in an integrated manner in the schools to promote in the students, the appreciation of practical application of basic ideas [2]. To this end, the place of chemistry in the national secondary schools' curriculum in preparing students to become future scientist and also in supporting them to think and act the way scientists do is of great importance.

Chemistry has been defined as a science of nature and one that deals with the properties of non-living substances, whose properties ranges from the preparation and changes that they undergo when such substances are subjected to adverse conditions of high temperature, high pressure, extreme cold and abnormal contact[3]. Chemistry as a branch of natural sciences occupies an important place in the secondary school curriculum. As an

academic discipline, it is highly admirable as it even creates a sense of excitement among learners. Its inclusion in the curricula of secondary schools and Technical colleges of Education has been justified (for attracting youths to careers with chemistry options) and commended as innovative (for creating wealth of experience for the educated citizenry)[4]. The specific objectives to be achieved for Chemistry in the curriculum as stated in the report of Nigerian Educational Research and Development Council (NERDC) includes: providing students with the basic knowledge in chemical concepts and principles through efficient selection of content and sequential, showing Chemistry and its inter-relationship with other subjects and providing reasonable and adequate foundation for post-secondary school chemistry courses [2]. Chemistry curriculum is designed in such a way as to show inter-relationships between the subject (chemistry) and other science subjects (biology and physics) and to satisfy requirements for senior secondary school programme in the National Policy on Education. Students are required to learn chemistry by understanding, which demands a mastery of reasoning capabilities of students at the formal operational stage.

The objectives of secondary school chemistry curriculum therefore, as specified in the Senior Secondary School syllabus are as follows ; To facilitate transition in the use of scientific concepts and techniques acquired in integrated science (now basic science) with chemistry. Also to provide basic knowledge in chemistry concepts and principles through efficient selection of contents and sequencing. In addition, to show inter-relationships between chemistry and other science subjects, to show chemistry and its link with the industry, everyday life, hazards and benefits, and to provide students not proceeding for higher education with adequate foundation for other future careers[3].

The relevance of chemistry to national development is inestimable. The teaching of chemistry helps to imbibe scientific knowledge and stimulate science oriented attitude in learners. This attitude when directed to the world of work results in the development of the individual, the society and general standard of living of the citizenry. Therefore, the place of chemistry knowledge and skills in economic and industrial development in the Nigerian society cannot be underestimated. Chemistry is preoccupied with the molecular transformation, which matter, manifests [5]. Actually Chemistry goes beyond processes in chemical industries to other industries such as fertilizers, petroleum, paper and pulp, iron and steel, cement, coal, glass, electronics and so on. It plays major roles in the vital sectors of the economy, execution of other professions and improvement of quality life. Chemistry contributes immensely also in the area of medicine, agriculture and criminology. All the above are indicators that chemistry plays an important role in the economy and national development of any nation and as such should be considered essential and hence, be fully involved in the task of national and human development of Nigeria.

The uniqueness of chemistry makes it occupy a pride of place in the scientific and technological development of any nation. Physical chemistry is a branch of chemistry that explores the fundamental principles governing chemical systems and processes. It combines concepts from physics and chemistry to understand and predict the behavior of matter at both macroscopic and molecular levels. It is foundational for advancing scientific research and technological innovation. By bridging the gap between theory and experiment, it provides tools for solving complex chemical and physical problems in various fields. However, Physical chemistry is widely perceived as abstract and difficult by both students' and teachers and as a result majority of the students essentially engage in rote learning [6]. The role

of physical chemistry in our daily and national life as well as in the industry is undaunted. Many of our day-today activities revolve around physical chemistry. Chemistry is everywhere; chemistry is life; physical chemistry is the oracle and crown prince of modern science [7,]. Despite the key role of Chemistry as the central science that forms the basic foundation to many disciplines and in improving the quality of life, the performance of Nigeria secondary students in the subject has for many years remained a matter of a serious concern [8,].

Academic achievement is a very important factor in education. It is the extent to which a student, teacher or institution has achieved their educational goals[9]. Academic achievement refers to particular learning in a particular setting which is defined by examination marks, teachers' given grades and percentiles in academic subjects[10]. It is undoubtedly a research after the heart of many educational psychologists, who make an attempt to investigate what determines academic outcomes of students[11]. The attainment of success by a student in his/her school work among his classmates is termed academic achievement[12]. Academic achievement is usually employed to describe an individual's performance in subjects taught and tested in schools. It also refers to the level of education ultimately attained by an individual[13]. It has been observed that students with high academic achievement are predisposed to feel more convinced and satisfied than those with poor academic achievement. Also students who obtain higher academic achievement tend to feel more confident, whereas those who lack confidence in themselves record low academic achievement. Academic achievement is sometimes viewed as the amount of content learned by students[14]. It is measured by intelligence (example; intelligence quotient) and standardized tests in core subject areas (example; mathematics, chemistry and Physics).

Academic achievement is mostly measured using examinations or continuous assessment but there is no conclusive agreement on how best it is tested or which aspect are most necessary. The differences in academic achievements can be attributed to various factors like intelligence, creativity, self-esteem, cognitive style, achievement motivation, instructional strategy, self efficacy, personality and many other[15]. Now, schools are receiving money based on its students' academic achievements. A school with more academic achievements would receive more money than a school with less achievements[16]. Therefore, academic achievement should be considered to be a multifaceted construct that comprises different domains of learning. Because the field of academic achievement is very wide ranging and covers a broad variety of educational outcomes, the definition of academic achievement depends on the indicators used to measure it. Among the many criteria that indicate academic achievement, there are very general indicators such as procedural and declarative knowledge acquired in an educational system, more curricular based criteria such as grades or performance on an educational achievement test, and cumulative indicators of academic achievement such as educational degrees and certificates. All criteria have in common that they represent intellectual endeavors and thus, more or less, mirror the intellectual capacity of a person. In developed societies, academic achievement plays an important role in every person's life. Academic achievement as measured by the GPA (grade point average) or by standardized assessments designed for selection purpose such as the Scholastic Assessment Test (SAT) determines whether a student will have the opportunity to continue his or her education (., to attend a university). Therefore, academic achievement defines whether one can take part in higher education, and based on the educational degrees one attains, influences one's vocational career after education. Besides the relevance for an

individual, academic achievement is of utmost importance for the wealth of a nation and its prosperity [12].

Students' academic performance in any subject is an important index for measuring the effectiveness of teaching/learning and the extent to which the intended objectives of the subjects are being achieved. Any malfunction during the teaching/learning process can result in students' poor performance. Students perform poorly in chemistry, a central science subject. This situation is evident in the frequent poor achievement of Nigerian students as measured by their cognitive achievement in the May/June and November/December Senior School Certificate Examination (SSCE) for chemistry. However, record of analysis of students' results in chemistry and other science subjects such as physics and biology for a number of years has revealed dismal failure, with chemistry being the poorest[17].

Research has shown that students do not enter the classroom as a "blank slate"[18]. Students' construct knowledge by making connections between new information and their existing conceptual network. "Learning is an active process of knowledge construction, the making of connections between existing network of knowledge"[19]. Students' prior conceptions, ideas and experiences which they carry to the classroom influence the way they learn new concepts and skills[20]. Hence, it is important that they are actively engaged in the learning process and that they are challenged to reflect on their own learning besides being able to link their prior knowledge to new knowledge. Certain studies done in Nigeria suggest that teachers are in a hurry and tend to rush through the scheme of work to enable them cover the topics in the curriculum within the given period [21, 22,23].

Efforts made through research to discover the causes of the persistent failure revealed among others, that secondary school chemistry teachers mainly adopt the conventional

method in the teaching and learning of chemistry[24]. “Teaching is not an incidental craft to follow naturally from mastery of subject content, but a highly complex blend of theoretical understanding and practical skill”[25]. Emphasis on traditional approaches and coverage of content mapped out in the school syllabus and scheme of work for the three years of senior secondary education (Nigeria runs 6-3-3-4 system on education although with the introduction of 9-3-4 system, the senior secondary position has not changed) in Nigeria have resulted to students learning chemistry without conceptual understanding[26]. Despite efforts of Chemistry teachers and educators to improve students’ learning outcome, students have continued to show weakness in meaningful understanding and internalization of chemical concepts, leading to poor performances in external Chemistry examinations[17].

Chemistry is a subject that can be taught by applying different strategies. Therefore, the teacher is able to use different teaching approaches during the teaching and learning process of chemistry. This can be done by combining more than one teaching approach in one lesson session or using one teaching approach for that single lesson session. Some might be teacher-centered, while others are involved in the student-centered approach, which is the preferred worldwide approach. This gives the teachers the only choice of using a student-centered approach. Considering that the choice of teaching technique or method is not random, teachers need to be supported with the most effective teaching technique for the specific topic instead of generalization based on what is used easiest or preferred one[27].

Physical chemistry is claimed to be a complex concept to teach and learn. For a chemistry teacher to be more successful in teaching physical chemistry, he or she needs to take into account different aspects that range from chemistry itself in the learning environment and the prior knowledge of the student; then reinforce the engagement of the

student in the whole process of teaching and learning[28]. Policymakers now recognize students' engagement as important in the teaching and learning process, and students should be brought to the stakeholders' level towards improved learning outcomes. Students need to be motivated and interested in the teaching and learning process through a total engagement, linking the learning to the real-life situation for better performance[29].

However, teaching methods play important role towards the success or other wise of the teaching and learning process. Teaching methods which support the learner to have control over his/her learning should always be encourage by all education stakeholders. These teaching methods are regarded as learner –centered methods, they includes among others inquiry, problem solving, demonstration, cooperative, guided discovery, project, laboratory, Activity-based, field trip and excursion methods. These methods when used by the teachers appropriately, improves performance and retention ability of students in science subjects particularly chemistry[30].

Poor and inappropriate teaching methods adopted by science teachers during instruction and the absence of instructional materials in science classrooms have been identified as the principal causes of high rates of failures in science examinations[31]. It was observed that teachers still rely heavily on didactic methods and teach science as a body of knowledge needed only to be memorized for success in examinations and which the students often forget shortly afterwards. Moreso, some scholars strongly submitted that the abstract nature and the difficulty in learning some concepts are so stable and coherent internally that conventional instruction has little effect on them[32]. Since the goal of instruction is to develop educational experiences that will facilitate meaningful learning and reduce rote memorization, physical chemistry instruction should deliberately stress effective knowledge transfer to the

student in the most efficient and purposeful manner. Teachers need to create a suitable environment by employing strategies that encourage active student participation in identification of issues, concepts and relationships which will be far more effective than the traditional practices whereby students are passive recipients of knowledge with no cognitive involvement in the learning process[33]. Besides, the most important derivatives of learning are knowledge retention and application to real life situations outside the classroom. In order to learn a concept meaningfully, students must carry out cognitive processes that construct relations among the elements of information in the concept to promote conceptual learning over rote memorization.

Due to the very dynamic nature of chemistry and in order to catch up with the new world order of scientific and technological innovations, there must be a drastic change in the method of presentation and delivery of individual concepts in chemistry classrooms and laboratories. This could be achieved through the use of innovative and student-centered approaches in handling abstract and difficult concepts like Physical chemistry. It has therefore become a pedagogical necessity to search for innovative, student-centered approaches such as guided discovery and activity-based strategies which could scaffold instruction and ensure that specific aspects of concepts are meaningful learnt and internalized. This could actively involve the students in the learning process, and perhaps make learning more meaningful and enjoyable.

Guided discovery instructional strategy is generally defined as instruction in which learners construct essential information for themselves with minimum guidance from the teacher. Learners play an active role in groups starting from the problem statement, data collection and processing, data verification to concluding their findings. Active learning

requires a hands-on approach and requires learners to engage their minds in the process of inquiry learning[34]. One of the theories neglected in the teaching of science is the constructivism model. Constructivists believe in designing activities where learners are actively learning to gain knowledge rather than transmitting knowledge. Constructivist theorists believe that teachers should deal with learners having high abilities or high motivation for science and be concerned with different levels of learners' cognitive and affective dimensions. Here, the teacher's guidance is crucial for the learning process. Four Guided discovery instructional strategy tenets include: Task setting, which involves the teacher showing an open-ended question and telling the first part of a story and leaving the next part open to interpretation , collaboration ; where learners communicate, monitoring how well the learners are progressing and scaffolding them whenever they face challenges and consolidating concepts, which requires learners to think aloud, do self-question, examine steps they took to conclude, and to derive meanings of what is learnt[35].

Furthermore Activity-based instructional strategy as the name suggests is a process whereby learners are actively engaged in the learning process, rather than "passively" absorbing lectures. It is based on the core premise that learning should be based on doing some hands- on experiments and activities rather than just listening to lessons. Activity-based learning involves reading, writing, discussion, practical activities and engagement in solving problems, analysis, synthesis and evaluation. Active learning is also defined as any strategy "that involves student in doing things and thinking about things they are doing". Activity based teaching is an approach to education focusing on the idea that students should be engaged through actions. This is in contrast to some traditional forms of teaching in which an educator lectures or otherwise relays information to students who are expected to absorb

what they are told. In activity-based teaching, an educator serves the function of facilitator, assisting students through the learning process and providing them with guidance. Various actions and tasks can be used in this type of programme, allowing students to become directly involved in the learning process, rather than remaining passive.

Hands on activities are situations whereby a learner uses his/her hands in carrying out concrete activities that could enhance his/her learning experiences[36]. It is also described as a method of teaching whereby students are engaged actively in class activities with the use of their hands and intellect under the guidance of the teacher[37]. Hands-on activities by implication show that students have objects directly available for investigation. Other terms for hands-on activities include material centered activities, manipulative activities, and practical activities[36].

Teaching and learning processes which involves hands-on activities is believed to help students in understanding theories and principles which are difficult or abstract. A meta-analysis of the effectiveness of hands-on activities suggested that students may acquire more knowledge in short term when taught conventionally but are likely to retain knowledge longer when taught with hands-on activities teaching/learning method[38]. Hands-on activity is more effective than traditional instruction that it result in better long-term retention and academic performance than traditional methods of teaching[39]. The basic goal of a teacher is to involve students in the learning process. These processes should be according to the Intended Learning Outcomes (ILOs). It should be remembered that what the student do is more important than what the teacher does. However, the learning activity should be intentional, meaningful, and useful. Activities should build on previous knowledge. It should enable students to engage with and develop their skills, knowledge and comprehension

through these activities. The activities should also be useful for other activities. The useful learning activities are those activities that can be used in other activities with a different context. Activities that are used in educational setup are the following: dramatization, gamification / quizzes, group discussion, role play and simulation, brain storming, problem-solving, discovery learning, projects-based learning, experimentation and concept mapping. These are by no means an exhaustive list. Any activity can be used which can be the best fit according to the needs and ILOs [40].

Gender is also a crucial variable that will be considered in this study. Gender inequality in science and education in general has remained a perennial problem of global scope[36]. In Nigeria, it has become an issue of concern in some years back. As schools and educational institutions are more structured, gender difference takes up new and more focus of researchers. Gender relates to the difference in sex (that is, either male or female) and how this quality affects their dispositions and perception toward life and academic activities [37].The differences between boys and girls in relation to chemistry achievement have received a lot of attention. Studies on gender differences in chemistry achievement continue to yield inconsistent results and it has usually been attributed to unequal exposure of males and females to learning instructions relevant to chemistry learning[42]. Therefore, it is of interest to find out if the difference in sex of students could affect their achievement in physical chemistry using guided discovery and activity-based instructional strategies.

1.2 Statement of the Problem

Chemistry has been recognized as a central science subject in secondary schools in Nigeria and therefore it is important to the development of Nigeria as a nation. Chemistry being a core science subject at the senior secondary school level of education is expected to

serve as a base for scientific and technological knowledge that will enable the child to fit into the scientifically and technologically progressive society. However, students' inability to solve problem that requires calculation, students' struggle to integrate content learnt in the classroom and laboratory which leads to incessant poor performance of students in Chemistry especially in private and public schools and in Nigeria have been a major concern to researchers. This situation is evident in the frequent poor achievement of Nigerian students as measured by their cognitive achievement in the May/June and November/December Senior School Certificate Examination (SSCE) for chemistry. However, record of analysis of students' results in chemistry and other science subjects such as physics and biology for a number of years has revealed dismal failure, with chemistry being the poorest[17].

It has also been observed that some teachers still rely heavily on conventional methods and teach Chemistry as a body of knowledge needed only to be memorized for success in examinations and which the students often forget shortly afterwards, so many teachers are in a hurry and tend to rush through the scheme of work to enable them cover the topics in the curriculum within the given period. Despite the availability of chemistry laboratory, well trained and qualified teachers, use of instructional materials and conventional teaching strategy by the teachers, low achievement in Chemistry by students appears to have persisted. The annual release of Senior Secondary Certificate Examination (SSCE) conducted by West African Examination Council (WAEC) justifies the problematic nature and generalization of poor secondary school students' performance in Physical Chemistry concept. One now begin to wonder what would be responsible for this trend? This now suggests that variables that enhance achievement or performance in school are not mainly cognitive and non-cognitive but other variables could also have effect on student

academic achievement. Based on this premise, the study determined the effects of activity–based and guided discovery strategies on students' academic achievement in Physical Chemistry in secondary schools in Lagos west senatorial district of Lagos state.

1.3 Aim and Objectives of the Study

The main aim of this study was to determined the effect of guided discovery and activity–based instructional strategies on academic achievement of Senior Secondary School Students' in Physical Chemistry in Lagos West Senatorial District of Lagos State. Specifically, this study:

i. Determined the main effect of treatment (guided discovery, activity-based and conventional instructional strategies) on senior secondary school students academic achievement in physical chemistry
ii. Examined the main effect of gender on senior secondary school students academic achievement in physical chemistry;
iii. investigated the interaction effect of treatments (guided discovery, activity-based and conventional instructional strategies) and gender on senior secondary school students academic achievement in physical chemistry;

1.4 Hypotheses

The following null hypotheses were formulated and tested at $p \leq 0.05$ alpha level based on the stated objectives:

$H_0$1: There will be no significant main effect of treatment on senior secondary school students' academic achievement in physical chemistry.

$H_0$2: There will be no significant main effect of gender on senior secondary school students' academic achievement in physical chemistry.

$H_0$3: There will be no significant interaction effect of treatment and gender on senior secondary school students' academic achievement in physical chemistry

1.5 Significance of the Study

The findings of this study would be helpful to the following stakeholders who play important roles in developing skills and increasing level of students' achievement: teachers, school administrators, policy makers and curriculum planners and students.

It would help Chemistry teachers to create a suitable environment for learning by employing strategies that encourage active student participation in teaching and learning process, and are capable of improving the achievement of students rather than relying on conventional strategy for teaching physical chemistry.

It would help school administrators to see the need to motivate and encourage their Chemistry teachers to engage the students in activities during class instructions. It would also encourage them to make it a priority to furnish their chemistry laboratory with standard equipment and instructional materials where students can learn by doing and discover new things themselves. In the same vein this could provide school administrators the opportunity for self-evaluation and necessary adjustment.

It would provide relevant information to curriculum planners and policy makers to plan the curriculum and formulate policies that could encourage the use of instructional strategies that are student–centered, and to organize seminars, conferences and workshops for chemistry teachers in order to improve students' academic achievement in physical chemistry.

It would be of benefit to the students as it motivates them to learn and have a better understanding of how to solve problems in physical chemistry thereby improving their achievement in it.

1.6 Scope of the Study

This study determined the effect of effect of guided discovery and activity–based instructional strategies on senior secondary school two students' academic achievement in physical chemistry in Lagos West Senatorial District, Lagos State. The study focused on SSII chemistry students because it is the only class that has physical chemistry topics in their Scheme of Work. The study covered four sub-topics under electrolysis which includes; terms used in electrolysis, ionic theory, Faraday laws of electrolysis and the application of electrolysis selected from the SSII scheme of work. The choice of the sub-topics was with the consideration to help students overcome the difficulties associated with achievement in electrolysis as one of the areas that is problematic to Chemistry students as reported by the Chief Examiner's for West African Examination Council (WAEC).

1.7 Limitation of the Study

The problems encountered during the course of this study include:

i. sourcing for materials for the research title was a bit tasking;

ii. during the administration of the instruments, some students were not consistent in attendance, and this affects the number of samples used;

iii. difficulties were encountered in fitting the time for the administration of the instrument to the school timetable;

iv. some of the sample school teachers, who served as research assistants, were unwilling to cooperate until they were motivated.

In spite of all these limitations, the instruments were administered and the research was carried out successfully.

1.8 Operational Definition of Terms

The terms used in this research are defined operationally as follows:

Achievement in Physical chemistry: This is the learning outcome or attainment of students taught physical chemistry using guided discovery and activity-based strategies as expressed in scores.

Physical Chemistry: Physical Chemistry is one of the aspect of chemistry that is been studied in SS2 according to the scheme of work and WAEC syllabus. For this study the concept of electrolysis was considered.

Gender: This is the difference between male and female in relation to achievement in physical chemistry

Guided discovery: It is a strategy whereby chemistry students for this study generally construct essential information for themselves with minimum guidance from the teacher, whereby students play an active role in their various groups.

Activity-based: This is strategy a whereby chemistry students for this study are engaged actively in class activities with the use of their hands and intellect under the supervision of the teacher in carrying out activities involving aspects of electrolysis.

Conventional Strategy: It is a strategy whereby the teacher for this study do the talking alone (talk and chalk method) and the students are passive throughout the instructional process.

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Chapter Two

Literature Review

This chapter presents the review of related literature under guided discovery and activity-based strategies on secondary school students' academic achievement in physical chemistry in Lagos State.

2.1 Conceptual Review

2.1.1 Academic Achievement

2.1.2 Physical Chemistry

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2.3.1 Guided Discovery Strategy and secondary school students Academic Achievement in Physical Chemistry

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2.3.3 Gender and physical chemistry achievement

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2.5 Summary of Literature Reviewed

2.1.1 Academic Achievement

Academic achievement is a very important factor in education. It is the extent to which a student, teacher or institution has achieved their educational goals[1]. Academic achievement refers to particular learning in a particular setting which is defined by examination marks, teachers' given grades and percentiles in academic subjects[2]. Academic achievement maybe defined as a measure of knowledge, understanding or skills in a specific subject or a group of subjects. Academic achievement is one of the most important indicators of learning and understanding in all educational systems. It is undoubtedly a research after the heart of many educational psychologists, who make an attempt to investigate what determines academic outcomes of learners[3].

The attainment of success by a student in his school work among his classmates is termed academic achievement[4]. Academic achievement is also defined as the ability of a student to study and remember facts and being able to communicate his knowledge orally or in written form even in an examination condition[5]. The authors also opined that academic achievement is a measurable index that depicts a student's cognitive, affective and psychomotor domains in educational setting. It is simply defined as how well an individual has done in his cognitive tasks. It is the general ability of students regarding their performance in school subjects compared to a specified standard called 'pass mark[6]. Thereafter, academic achievement refers to the observed and measured aspects of a student's mastery of skills and subject contents as measured with valid and reliable tests[5].

Academic achievement is usually employed to describe an individual's performance in subjects taught and tested in schools. It also refers to the level of education ultimately attained by an individual[7]. It has observed that students with high academic achievement are

predisposed to feel more convinced and satisfied than those with poor academic achievement. Also students who obtain higher academic achievement tend to feel more confident, whereas those who lack confidence in themselves record low academic achievement. Academic achievement is sometimes viewed as the amount of content learned by students[8]. It is measured by intelligence (example Intelligence quotient) and standardized tests in core subject areas (example mathematics, chemistry, physics). Academic achievement is mostly measured using examinations or continuous assessment but there is no conclusive agreement on how best it is tested or which aspect are most necessary.

The differences in academic achievements can be attributed to various factors like intelligence, creativity, self-esteem, cognitive style, achievement motivation, instructional strategy, self efficacy, personality and many others[9]. It is commonly measured through examinations or continuous assessments but there is no general agreement on how it is best evaluated or which aspects are most important—procedural knowledge such as skills or declarative knowledge such as facts[10]. Now, schools are receiving money based on its students' academic achievements. A school with more academic achievements would receive more money than a school with less achievements[11]. Academic achievement is often measured through examinations or continuous assessments. Academic achievement is the extent to which a student or institution has achieved either short or long term educational goals. Achievement may be measured through students' grade point average, whereas for institutions, achievement may be measured through graduation rates [12]. Therefore, academic achievement should be considered to be a multifaceted construct that comprises different domains of learning. Because the field of academic achievement is very wide ranging and covers a broad variety of educational outcomes, the definition of academic achievement

depends on the indicators used to measure it. Among the many criteria that indicate academic achievement, there are very general indicators such as procedural and declarative knowledge acquired in an educational system, more curricular based criteria such as grades or performance on an educational achievement test, and cumulative indicators of academic achievement such as educational degrees and certificates. All criteria have in common that they represent intellectual endeavors and thus, more or less, mirror the intellectual capacity of a person. In developed societies, academic achievement plays an important role in every person's life. Academic achievement as measured by the GPA (grade point average) or by standardized assessments designed for selection purpose such as the SAT (Scholastic Assessment Test) determines whether a student will have the opportunity to continue his or her education (e.g., to attend a university). Therefore, academic achievement defines whether one can take part in higher education, and based on the educational degrees one attains, influences one's vocational career after education. Besides the relevance for an individual, academic achievement is of utmost importance for the wealth of a nation and its prosperity[3].

2.1.2 Physical Chemistry

Physical chemistry deals with the principles of physics involved in chemical interactions. Physical chemists are focused on understanding the physical properties of atoms and molecules, the way chemical reactions work, and what these properties reveal. Their discoveries are based on understanding chemical properties and describing their behavior using theories of physics and mathematical computations. Physical chemistry is a good area for chemists who have a strong curiosity about how things work at the atomic level and enjoy working with laboratory instrumentation and machines. They use sophisticated

instrumentation and equipment such as lasers, mass spectrometers, nuclear magnetic resonance, and electron microscopes to; analyze materials, develop methods to test and characterize the properties of materials, develop theories about these properties and discover the potential use of the materials. Physical chemists stress the importance of applying mathematics on the job. They use mathematical analysis and statistics on huge datasets, sometimes with millions of data points to reveal hidden information about compounds, materials, and processes. They may also conduct simulations, developing mathematical equations that predict how compounds will react over time. Physical chemistry provides broad training and positions students to work in a variety of scientific careers, such as; emerging fields of materials science and molecular modeling - **c**ombining the traditional mathematical rigor of physical chemistry with the practicality of these fields offers new and exciting possibilities, careers in analytical chemistry whereby students work to understand the fundamental processes involved in analytical techniques, and look for ways to enhance and expand them[13].

Physical chemistry is a branch of chemistry that focuses on how matter behaves at the molecular and atomic levels and how chemical reactions occur, which results in the development of new theories, such as how complex structures are formed. Physical chemistry is regarded as a challenging subject to teach and learn at both the secondary and tertiary levels. This is partly because a solid grasp of physicochemical concepts requires proficiency in mathematics even though the transference of mathematical skills into applied subjects is not straightforward. Major learning difficulties could be caused by learners' perceptions of chemical phenomena and concepts, which appear abstract and difficult to understand, as well as their relationship to everyday life. As a result, misunderstandings occur when students

attempt to understand chemical explanations within the context of the instruction provided but are unable to interact with this concept due to difficulty encountered. It could be due to their lack of fundamental scientific knowledge or scientific concepts. If there is no conceptual understanding of concepts and topics, chemistry may not be appealing and this may affect the learner's level of interest and curiosity[14]. Scientific concepts especially chemical concepts requires understanding of chemical phenomena at three interlinked levels namely macroscopic (phenomena that we can see, feel, and hear), symbolic (chemical formulas and equations), and sub-microscopic (individual atoms and molecules), and the relation among the three. However, most of the times, teachers focus only on one level, usually at the macroscopic and representation parts, microscopic parts are sometimes of forgotten and most explored. This causes students to often have difficulty in understanding and visualizing microscopic concepts such as atom, molecules, or chemical reaction. Physical chemistry difficulty can be traced back to the nature of science itself, the method by which the subject has been taught and the method by which students learn. Thus, teachers' acquisition of appropriate scientific and technological skills, as well as their ability to impart knowledge to students, will aid in improving performance. Students must actively participate in the learning process by constantly equipping, testing, speculating and building their construct and knowledge. They perceive the subject as abstract if they are not taught or carried along in the teaching. According to the five pillars of effective learning, learning should be active, gender-sensitive, consistent, meaningful, and productive[15]. Thus, for effective learning to occur, the learner must be active in the classroom, both males and females must be carried along equally, the learning must be consistent with the curriculum and the societal goals, the concepts learned must relate to the needs of everyday life and the

society and the learners must be able to produce items and products required by the society as needed[14].

The study of chemistry at all educational levels necessitates knowledge, a logical thought process and numerical ability. Mathematics is a necessary and integral part of all scientific disciplines. Mathematics, Physics and Chemistry are essential science subjects at the senior secondary school level in Nigeria and serves as the bedrock of many subjects in the secondary school curriculum especially those that are science related. In this scientific age, having a basic understanding of mathematics and numeracy allows students to understand and solve some important chemistry problems in terms of concepts and principles. For example, knowledge gained from learning concepts such as fractions, ratios and proportions, percentages, the function of integration and differentiation in mathematics could be used to solve numerical problems in chemistry such as solution mixing and dilutions, mole concept, stoichiometry reactions, acid-base reactions and gas laws. Furthermore, the understanding of indices and logarithms in mathematics could be applied to the understanding of the pH scale and rate of reactions in Chemistry[16]. Many researchers and chemistry educators believe that mathematics is one of the issues impeding students' progress in chemistry. This demonstrates that learning chemistry necessitates several mathematical concepts and principles for easy comprehension and understanding. Furthermore, success in physical chemistry is not solely dependent on mathematical ability, as logical thinking and conceptual understanding are crucial in mastering physicochemical topics. Indeed, past research has documented a prevalence of alternative conceptions that stem from previous instruction, or from the commonplace use of concepts like temperature and work.

Apart from the abstract and mathematical nature of concepts, physical chemistry also poses challenges due to factors such as instructor-centred pedagogical approaches, excessive course content, limited resources, and waning student motivation. Consequently, many students enter physical chemistry courses with negative perceptions and low expectations of success[17].

2.1.3 Guided discovery Instructional Strategy

Guided-discovery technique is one of the teaching techniques that encourage students to play more active role in the learning process through answering of series of questions or problems solving designed to introduce a general concept[18]. In this teaching approach, the teacher guides the students' thought process by posing at them a series of questions whose responses would lead the students to the understanding of what is explicitly stated. This teaching technique is assumed to increase retention of materials because the students acquire the new information and integrates it with already stored information[19]. Guided-discovery is a method by which inquiry skills and information processing skills are developed by learners. Learners are totally involved with people, materials, and the environment, but are however using this awareness to generate concepts and facts. Guided-discovery is characterized by convergent thinking. The instructor devises a series of statement or questions that guide the learner step by step into making a series of discoveries that lead to a single predetermined goal. In other words, the instructor initiates a stimulus and the learner reacts by engaging in active inquiry that lead to discovering the appropriate responses [20].

Students tend to learn better and deeper when required to search, discover, and build essential information. Guided discovery learning encourages students to learn autonomously, discover a variety of learning contents, and actively construct their knowledge under the

guidance of the teacher. Teachers play significant roles in discovery activities in terms of providing innovation, guidance, and direction. The guidance provided by the teacher is not a rule of thumb that must be followed instead of the needed work procedure direction. It requires students to be fully and actively involved in learning by investigating and discovering their own knowledge that is properly monitored by a teache[21].

Guided discovery unlike the lecture method of instruction is student-centered and activity-oriented where the teacher assists students to discover facts about problems and gain experience. Here the teacher presents students with information in a form that requires them to design relationships within the information and to structure and make sense out of it. Learning by discovery will be a powerful method for teaching meaningful information which in turn would have a positive effect on long-term retention. The key features of guided discovery are context and frame for student learning through the provision of learning outcomes, learners have responsibility for the exploration of content necessary for understanding through self-directed learning, study guides are used to facilitate and guide self-directed learning and understanding is reinforced through application in problem-oriented; task-based, and work-related experience.

Guided Discovery Instructional Strategy is generally defined as instruction in which learners construct essential information for themselves with minimum guidance from the teacher[22]. Learners play an active role in groups starting from the problem statement, data collection and processing, data verification to concluding their findings[23].

Guided discovery is the teaching method that employs exploration, manipulation and experimentation to find out new ideas, and it is a problem solving oriented strategy[24]. In other words, guided discovery instructional strategy is regarded as convergent thinking. The

instructor conceives a succession of declarations or questions that guide the learner, step by logical step, making a series of innovations that lead to a single predetermined goal. Succinctly, the teacher initiates a stimulus and the learner reacts by engaging inactive inquiry thereby discovering the appropriate response.

Five Core Benefits of Learning through Discovery

Engagement

Children are inherently curious. They learn through their experiences, solving mathematical operations by drawing on previous knowledge. As you advance towards teaching more complex concept, engage your students in math talks. Instead of solving equations on the board, and giving students the answer, have them talk through their process as they solve mathematical operations.

Better yet, make math social! Researchers at the University of Washington have found that making math social increases engagement and motivation when completing mathematical tasks and assignments.

Motivation

When your students are engaged, they become motivated to learn. A curiosity and motivation for math develops through this hands-on, discovery method of learning. It's no longer just the learning of math facts. When you engage your students in "chem talk", or ask questions while solving operations on the board, students begin to make connections in their heads.

Independence

Discovery learning promotes autonomy and independence. As your students actively engage in Chemistry, and progress through the curriculum, they are doing so at their own pace. The autonomy of discovery learning allows your students to progress only when ready. This keeps them further engaged, as well as encouraged. They are responsible for their own progress, and move forward only when mastering each level. Even when working in groups, or engaging in talks, students must first think independently and creatively to engage in problem-solving.

Retention

This high level of engagement leads to a much deeper understanding than passively listening to explanations. Through discovery and experimentation learning, levels of retention are exceedingly high.

Discovery learning emphasizes the importance of problem-solving, over the mere memorization of facts.

Rather than merely memorizing the correct answer, students learn to interpret and analyze new information. This method of learning is especially effective when applied to chemistry.

Life-long Results

Learning through discovery isn't about your students absorbing what is said or read to them. When applied to mathematics, this form of learning supports a strong number sense, and problem-solving abilities. Discovery learning is about actively searching for solutions: a skill your students will be able to use throughout their lives.

2.1.4 Activity-Based Instructional Strategy

Activity –based learning as the name suggests is a process whereby learners are actively engaged in the learning process, rather than "passively" absorbing lectures. It is based on the core premise that learning should be based on doing some hands- on experiments and activities rather than just listening to lessons. Activity- based learning involves reading, writing, discussion, practical activities and engagement in solving problems, analysis, synthesis and evaluation. Active learning is also defined as any strategy "that involves student in doing things and thinking about things they are doing". Activity based teaching is an approach to education focusing on the idea that students should be engaged through actions. This is in contrast to some traditional forms of teaching in which an educator lectures or otherwise relays information to students who are expected to absorb what they are told. In activity-based teaching, an educator serves the function of facilitator, assisting students through the learning process and providing them with guidance. Various actions and tasks can be used in this type of program, allowing students to become directly involved in the learning process, rather than remaining passive.

The purpose of activity-based teaching is for an educator to engage students directly, drawing them into a lesson so that they become a participant in their own learning. Some traditional forms of education often relied upon the educator as a knowledgeable expert who simply provided information to students. In this type of environment, the learners were expected to act as sponges that absorbed information, regardless of any particular type of effort made on their behalf. The students were taught, but there was not necessarily a focus upon them being a participant and actively learning while in a classroom.

In activity-based teaching, however, the educator uses different methods to draw the students into the lesson and make them a partner in their own education. The role of the teacher in this type of environment is to serve as a facilitator to the students, engaging them and making sure they become active in the learning process. This is often accomplished through the creation of different activities and projects that students work on as they learn. Activity-based teaching requires a great deal of effort on the part of the educator. Teachers using this method need to create lessons and plans that provide students with opportunities to take part in their education. Group work is quite common during activity-based teaching, since it allows students to take on the role of educator and work together to better understand different subjects. In these lessons, students work together in small groups to complete a particular project. Each group then presents information learned after performing the task assigned to it to the rest of the class. The educator in this form of activity-based teaching can observe each group and ensure they stay on task, but otherwise may not need to provide much additional information. As the groups present what they have learned, the teacher guides discussion and ensures that errors are not presented, though otherwise the students become responsible for their own learning.

Need of Activity Based Teaching Learning Strategy in Chemistry

i. Encourage independent and team learning
ii. Provide a wide variety of manipulative open- ended and creative activities.
iii. Provide students experience and active participation in the exploration of the environment

iv. Make student advance at their own rate the rate that is according to ability, interest and motivation

v. Emphasize problem-solving, critical and creative thinking and deep understanding.

vi. Encourage the learners to explore the new knowledge independently.

Activities that are used in educational setup are .dramatization, gamification / quizzes, group discussion, role play and simulation, brain storming, problem-solving, discovery learning, projects-based learning, experimentation and concept mapping. These are by no means an exhaustive list. Any activity can be used which can be the best fit according to the needs and ILOs.

Dramatization

Drama plays a vital role in student learning, especially language learning. It has made important contributions to understanding and appreciating cultural diversity. It encourages students to learn and improve innovation skills. Drama can guide students to learn, and can also improve language level. It can also enhance creativity[25]. Music in drama can also enhance and develop emotions. This also helps to build patriotism[26]. Participating in dramatization can enhance communication and writing skills[27].

A drama based on literary works is the source of students becoming creative writers and speakers. It helps to clear the understanding and imagination of literary works, because it involves the motives of the characters' actions, conveys tolerance and compassion. Besides, different scholars point out that the usage of drama in education is different areas, which are:

1. Promote learning motivation.

2. Enhance the motivation and enthusiasm for completing tasks.

3. It also reduces the pressure on language learning.

4. Develop auxiliary language communication (tone, pressure, speed, pause, etc.);

5. Develop voice control and the combination of body and language.

6. Enhance oral confidence in verbal and non-verbal communication;

7. Enrich language development.

8. Inspiration for language learning.

9. The drama also develops critical thinking and creativity.

10. Develop cooperation and teamwork skills.

11. It also increases real-world communication in the community.

Gamification / Quizzes

It is phenomena of today that there is a huge impact of the internet on the life of students. Internet is a strong factor which consumes a lot of time of students. Many platforms consume a lot of time of students such as Online games, Facebook, YouTube, WhatsApp, and Twitter, etc. Mobile devices are consuming a lot of time for students. Hence, technology has brought many changes in the life of students. Online games and socializing put a dual impact on students. On one side, they give their valuable time to these sites on the other hand they also affect the students' pattern of learning [28]. These factors distract the students to engage fully in study.

In this connection, a new trend has been introduced in education that influences the behavior of a person using games is called “gamification”. Gamification can be described as “the use of game design elements in non-game contexts”[29]. The term gamification is introduced in the recent digital media and after that, it is adopted by the educationists in 2010. Today it is used at a large scale in different categories such as education, entertainment, commerce, health, marketing, mobile, and websites, etc. These games are dedicated educational games because

they use pedagogy to incorporate instructions into the gaming experience. Creating a video game that can attract the attention of learners is a difficult task.

For student activities, including classroom attendance, contributions to tutorial questions, high-standard work, completion of tests, group assignments, answers to exam review questions, and group introductions games are used[30].

In this connection, the gamified quiz software tool, named Quick Quiz, was developed as a mobile web application. Quick Quiz was designed for instructional purpose which includes:

1. MCQs that did not need much thinking.
2. Limited time for answering a question.
3. Participation was voluntary.

Group discussion

Classroom discussion is an important tool in education. Discussion and debates can enhance critical thinking. There are numerous techniques available for this tool. It can be applied in any kind of education. Students may be assigned a topic and asked to defend the said topic. There are different strategies used to find the learning outcomes.

One of them is to promote such skills in students so that they may be able to see pro and con grids [31]. In this way, students were able to create grids with the pros and cons or advantages or disadvantages of a problem. After debating, students reported improvements in literature searching, weighing the risks and benefits of treatments, and making evidence-based decisions. There are many strategies and techniques for setting up discussion. Some steps should be kept in mind during the setting discussion in class.

In the first step, preparation is necessary for conducting a fruitful discussion. Enough time is necessary for creating an environment that enhances deliberative skills in students. It is

necessary to create such an environment in which students feel safe enough to express their ideas. For this purpose, an ice breaker activity may be conducted.

In step two it should be ensured that all students are involved in discussion preparation.

A teacher should understand his role especially in case of controversial issues. The discussion does not need an answer, but it shows a variety of viewpoints.

A teacher should always be a facilitator[32]. So, in step three a teacher must facilitate the students. They should be engaged in discussion. Initially, take a start with a small group discussion. The teacher should not interfere when students are silent on a given topic but s/he should give them a chance to think about it. If the problem remains, then s/he should rephrase the question for understandin[31]. Discussion may be opened with someone capable to speak with confidence. Avoid sensitive issues such as religious topics or sexual orientation.

In step four, a teacher should always conclude the debate in such a way that all unsaturated aspects are fulfilled. Discussion should close with a positive note.

Appreciate and acknowledge the student’s efforts and preparation in this regard.

Brainstorming

The purpose of using various teaching methods in different situations is to promote students' learning. Brainstorming is a way for a group to try to find a solution to a problem. Brainstorming is nothing new. In the past four hundred years, a method very similar to brainstorming has been used. The brainstorming method was originally proposed by Osborn in 1938. He used brainstorming to organize thought-seeking ideas.

There are some rules about brainstorming[32]. Teachers should keep these rules in mind before applying this method. The rules are as follows:

1. Criticism is not allowed under any circumstances. No one can criticize anyone's mistake. However, at the end of the meeting, opinions about different ideas can be discussed.
2. Dream flying: This means that during the meeting, all members should give up their restrictions. The logical and usual red lines should be crossed.
3. Focus on quantity: ideas can be easily classified.
4. Documents: Each idea should be recorded and provided if necessary.
5. Merge and improve ideas: ideas should be completed before discussion and evaluation. If necessary, it can be modified.

Therefore, it can be said that the brainstorming method can be used effectively by teachers.

Problem Solving

This method allows the students to solve the problems skillfully. Problem-solving methods usually employ concepts rather than processes. Problem-solving techniques are mainly used while teaching school subjects that are mainly composed of structured concepts [34]. The reason is that our students cannot solve problems outside the classroom. Students can only solve well-structured problems, only mentioned in textbooks [35]. Activity-based strategy strives to improve students' ability to solve this problem, and teachers should use this method by solving problems in daily life[36]. The terms "situational learning" and "holistic learning" are used for real-life learning experiences [33]

Discovery Learning

Discovery learning includes teaching models and strategies that focus on providing students with active hands-on learning opportunities. Three main characteristics of discovery learning are pointed out[37]. These are:

1. Explore and solve problems to create, integrate and generalize knowledge.
2. Student-oriented, interest-based activities, the order, and frequency are determined -by the students.
3. Encourage activities that integrate new knowledge into the learner's existing connections.

Through activities, students can build unique experience skills[37]. With this attribute, students can learn without a teacher. This attribute has changed the roles of teachers and students, and many teachers have no courage to face the new changes. The second characteristic of learning is to encourage students to believe in their abilities and learn at their speed. It is found that the third attribute of learning indicates that students can learn based on previous knowledge.

Project-based Learning (PBL)

Project-based learning (PBL) is a teaching method in which the students can learn content through the project. Students are required to use their previous knowledge to work on their projects. PBL procedure is proposed as part of interdisciplinary research in Greek middle schools[38], students are required to choose a specific part of Greek life that is attractive to them. Students choose specific subject areas, such as performing arts, visual arts, science, military, daily life, government, etc. After the students choose the theme, they will conduct an independent inquiry. Each student conducts an independent survey and writes a separate thesis.

Some students work on the project as a group. Students will use their multiple intelligences to prepare a 3-minute lecture as part of the Greek Life Museum. Lectures include theatrical performances of marathons, debates about the goddesses of Greek mythology in Athens

mythology, Greek dance, art, and more[39]. This is an example of how PBL works. The same projects may be used in other subjects too.

Concept Mapping

Due to a large amount of information, our students must obtain a lot of information to understand the content. But obtaining information does not guarantee that knowledge will be created, because information and knowledge are two different things with two different attributes. Therefore, we cannot say that information can acquire knowledge.

Information is regarded as raw data, while knowledge is the development of ideas. In other words, knowledge is produced by intellectuals. Concept maps prove the foundation of generative learning theory.

In generative learning, learners play an active role in concept mapping. The basis for generating learning models is personal thought. Information resources are not the basis for generating learning models[40].

Concept mapping occurs in two ways. By connecting different parts of external information in a meaningful way, it can develop patterns and create new knowledge.

The activities involved in concept mapping are classified as generative learning strategies. Learners can develop their concept maps and build meaningful learning. The relationship between concepts is the key to knowledge generation. Concept mapping is the process of giving meaning to content or information.

Barriers in Implementing Activity Based Teaching

As discussed above, many methods involve activity-based teaching in classrooms. Hence, barriers in implementation vary concerning the type of activity given to the students. Controversial issues are raised in the class hence unpredictable situation is developed. Moreover, teachers face problems to establish an environment conducive to activity-based teaching hence the students feel uneasy in the classrooms instead of enjoying the activities [40]. In this connection, it is pointed out that there is a lack of knowledge to conduct such activity in proper format by the teachers. Knowledge of different stages about various activities is essential for gaining fruitful results but there is a lack of such knowledge hence the essence of activity-based teaching is spoiled[41].

Although several studies concluded that games provided the learner useful skills which are beneficial for their course contents and also transferred the business world. Some scholars, on the other hand, think that there is a need to temper the games for the intrinsic value. The reasons for these phenomena are:

1. Recently applications of educational games are applied in the education sector.
2. The education sector is unaware of the use of serious games[36].

It is further indicated that activity-based teaching is also a threat to the discipline of the class. The students may quarrel resulting in insecurity of the students. During the activities uneven situations may exist and someone may react negatively. Body gestures may angry the other member which will lead to an uneven situation. Moreover, some activities are time-consuming which need a lot of time and money. Moreover, every student is not a performer so they may be reluctant to perform such activities. Social status also constitutes a hurdle in

role playing. If the students belong to different backgrounds and statuses, they may be reluctant to perform activities together[42].

2.1.5 Gender

Gender is a cultural construct developed by the society to distinguish the roles, behaviours, mental and emotional characteristics of males and females. There is difference between sex and gender, sex is a physical distinction while gender is a social and cultural one, thus responsibilities and opportunity or prospect of males and females are defined by societies and cultures, that is, men and women have certain way to behave and perform duties. It can also be viewed that males and females adapt differently to different teaching methods, strategies and approaches,

Gender issue in Nigeria has become an issue of concern in some years back. As schools and educational institutions are more structured, gender difference takes up new and more focus of researchers. Gender relates to the difference in sex (that is, either male or female) and how this quality affects their dispositions and perception toward life and academic activities[43]. Gender is seen as a socially/culturally constructed characteristics and roles, which are associated with males and females in any society[44]. Gender inequality in science and education in general has remained a perennial problem of global scope. The differences between boys and girls in relation to chemistry achievement have received a lot of attention.

2.2 Theoretical Framework

This study is anchored on two relevant theories. The first is known as Constructivism Learning Theory and the second is Experiential Learning Theory.

2.2.1 Constructivist Learning Theory

The study is based on the constructivist learning theory. It finds its antecedents from the works and philosophies of some influential psychologists who made significant contributions to the understanding of human learning and development. Learning is effective when learners are given the opportunity to discover facts by themselves , thus emphasis is laid on discovery learning[45]. Constructivist sees the acquisition of knowledge as an active process and thus encouraged learner's autonomy and personal involvement in the learning process. Learner's independence fostered through encouraging students to discover new principles on their own accord lies at the heart of effective education. Constructivist advocated for a spiral curriculum which can enable students to build upon what they have already learnt in the order of these principles.

1) Instruction must be commensurate with the experiences that make the students willing and able to learn (readiness).

2) Instruction must be structured such that it can be easily understood by the students (spiral organization).

3) Instruction should be designed to facilitate extrapolation (going beyond the information given). The implication of the theory to discovery approaches is that, teachers should create situations that would help learners to discover facts by themselves.

Constructivist theory is a general framework for instruction based upon the study of cognition. The task of the instructor is to translate information to be learned into a format appropriate to the learner's current state of understanding. The learner selects and transforms information, constructs hypotheses, and make decisions, relying on a cognitive structure to do so.

Social learning constructivist offers framework for instruction based upon the study of cognition[46]. Social learning constructivism centers on allowing students to actively interact with each other. They believe that, by allowing students to actively interact with one another, there will be opportunities for investigating, experimenting and asking questions, which will lead to getting answers that will make learning real and long lasting. The theory proffers that knowledge is situated and collaborative; therefore, knowledge is distributed among people and environment. It is important to note that constructivism is not a particular pedagogy. In fact, constructivism is a theory describing how learning happens, regardless of whether learners are using their experience to understand a lecture or following the instructions for building a model. However, constructivism is often associated with pedagogic approaches that promote active learning, or learning by doing.

One strategy for mastery learning in the classroom was described in details and suggested that teachers can develop many alternative strategies[47,48]. The strategy involves the supplementation of regular instruction with frequent formative educational procedures to find out the academic level of individual students. It also involves a variety of alternative instructional materials to try to bring as many students as possible up to predetermined standard of excellence.

Constructivist Theory

There are several constructivist models available that can be used for designing the proper learning experiences to the students. The 5 E's model can be conveniently implemented in science classroom. This model was developed under the Biological Science Curriculum Study (BSCS) project [48,49].

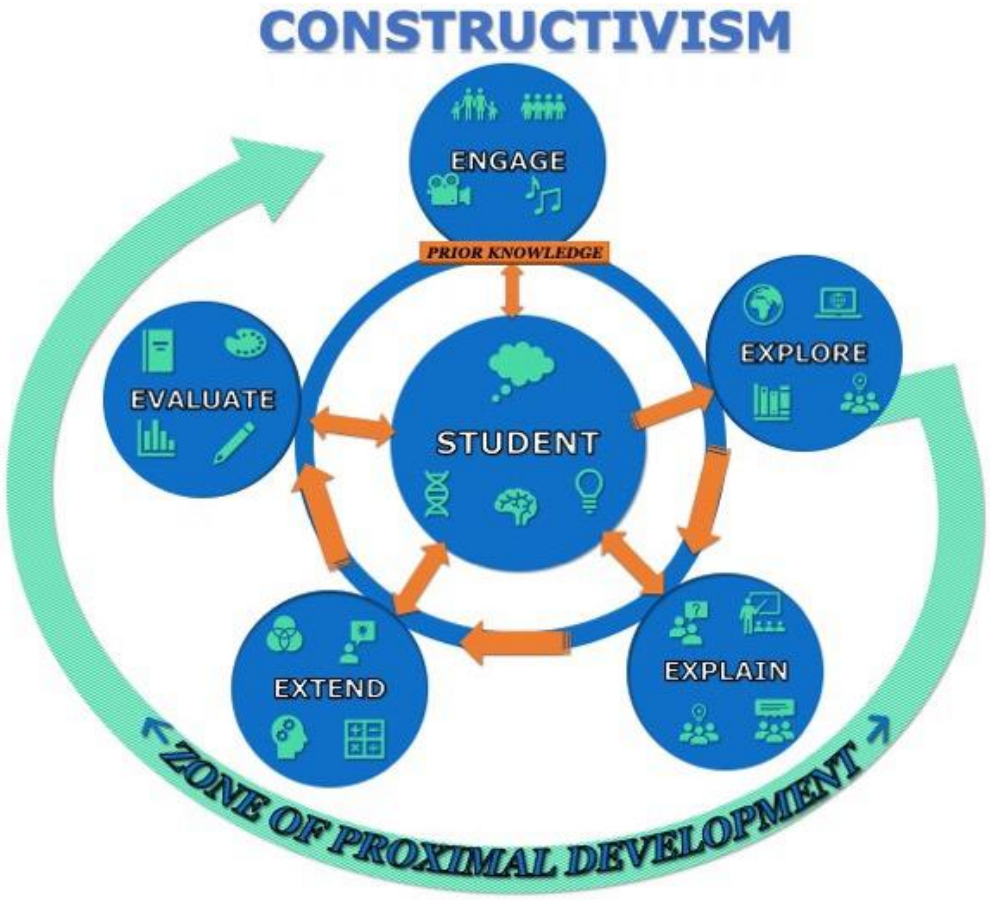

Figure 2.1: **Constructivist Theory**

The 5 ‘Es’ employs for Engage, Explore, Explain, Elaborate and Evaluate. The each of the 5 E’s describes a phase of learning, and these five “E”s can be further explained as:

Engage: This phase creates a connection between previous and present learning experiences and anticipate activities that focus students’ thinking on the learning outcomes of current activities. Students should become mentally engaged in the concept, process, or skill t to be

learned. Here, the role of the teacher is to present the situation and identify the instructional task.

Explore: In this phase teacher designed some learning activities so that students have common, concrete experience upon which they continue building concepts, processes, and skills. Engagement brings about disequilibrium; exploration initiates the process of restoring equilibrium. The aim of this phase is to establish experiences that teachers and students can use later for formal introduction and discussion of concepts, processes, or skills.

Explain: This phase of the 5 E's helps students for explaining the concepts they have been explored in previous step. Here, the teacher tries to focus student attention to specific aspects of the engagement and exploration experiences. The key to this phase is to present concepts, processes, or skills briefly, simply, clearly, and directly and move on to the next phase.

Elaborate: This phase of the 5 E's extends students' conceptual understanding and allows them to practice skills and behaviours.

Evaluate: This is the last phase of the 5 E's encourages learners to assess their understanding and abilities and lets teachers evaluate students' understanding of key concepts and skill development.

Therefore, from the theories discussed above, it is hoped that Chemistry students taught with guided discovery teaching method will develop interest in the learning process and construct their knowledge by linking it with existing knowledge to enhance meaningful learning, thereby aiding their retention ability and level.

2.2.2 Kolb's Experiential Learning Style

An ancient Chinese proverb is "I hear, and I forget. I see, and I remember. I do, and I understand". In this regard, four stages model was proposed , later a learning style was established[50]. In the experiential learning cycle the learner touches following basics:

i. Specific experience: This experience can be obtained by encountering new experience or situations or reinterpreting existing experience.

ii. Reflective observation of new experience: It includes any inconsistency between experience and understanding.

iii. Abstract conceptualization: Reflective observation of new experiences provides new concepts or remodeling of existing abstract concepts that people learn from experience.

iv. Active experiment: Learners apply their ideas to the world around them and see what happens.

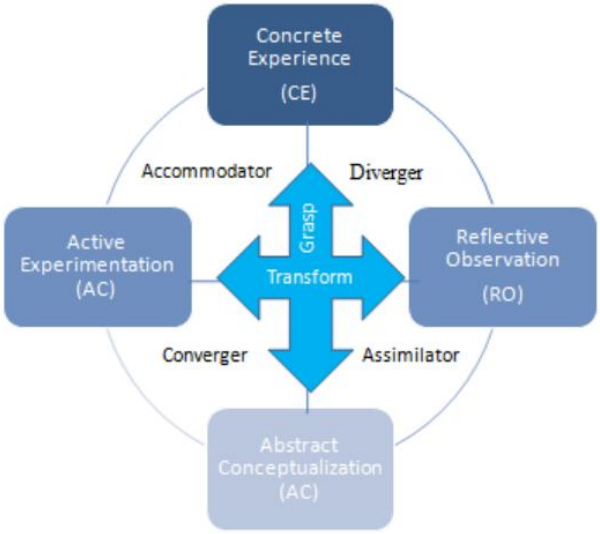

Figure 2.2: **The Experiential Learning Cycle and Basic Learning Style**[51]

Effective learning is seen when a person goes through these four stages of learning[51]. These stages of Experiential Learning Model are briefly described below.

1. First Stage: The first stage called the concrete experience (or "Activity") this is where the learner actively experiences an activity such as a lab session or field work. A person has concrete knowledge or experience, and this will lead to the next level.

2. Second Stage: The second stage is called reflective observation (or "Observe") this is when the learner consciously reflects back on that activity. One can observe and have a reflection on those experiences.

3. Third Stage: The third stage is called 'abstract conceptualization (for "Think") this is where the learner attempts to conceptualize a theory or model of what is observed. In this stage formation took place. Now concepts build through analysis and conclusions.

4. Fourth Stage: The final stage, active experimentation (for "Plan") this is where the learner is trying to plan how to test a model or theory or plan for a forthcoming activity. At this stage, concepts are used to test a hypothesis in future situations and as a result, a new experience is gained.

For effective learning, it is necessary to follow all these stages. No stage alone can be fruitful for learning[52]. Many scholars have hypothesized their studies to find out the effectiveness of activity-based teaching on the learning outcomes of a student. Educational activities emphasize the active role of learners nowadays. This role focuses on individual involvement during the course; therefore, it needs to create awareness of how a learner can engage in the learning process and how they can affect the learning outcomes. It is necessary to aware educators how learner's engagement in the learning process can change the success level. Today there is a severe need for new learning approaches. These approaches should be goal oriented and clear. This will help the learner to involve in learning experiences with full commitment. When we use the experience-based learning framework, then our students

become more active and progressive. They become more responsible towards their learning. They live in the real-life world and relate to things around them. This approach is considered much productive[53].

Experiential theory of learning by doing is relevant to this present study because, it emphasize the important of active involvement of the learner in concrete experience or activity using concrete materials. It gives an insight on the manner as well as procedural steps involved in learning by activity through a series of sequential arrangement of those activities for effective learning. It also emphasized that learning from experience or activity must involve links between the doing and the thinking. By implication, learning Physical Chemistry by doing may enhance reflection towards such activities, therefore, enhancing retaining ability of such activities. It is from the feelings and thoughts emerging from this reflection that generalizations or concepts can be generated. Therefore, its generalizations would enable new situations to be tackled effectively. The theory supports this study as its emphasis on hands-on concrete activities and direct involvement of the learner in the learning processes.

2.3 Review of Empirical Studies

2.3.1 Guided discovery Instructional Strategy and Secondary School Students Academic Achievement in Physical Chemistry

Some researchers conducted a study that investigated the effect of guided-discovery learning strategy on students' learning outcome in Mathematics alongside influence of gender with a sample of two hundred and two (202) SSI Students from two selected public co-educational schools in Ejigbo Local Government Area of Osun State[54]. The research was

a quasi-experimental design with a 20-item multiple choice Mathematics Achievement Test drawn from West African Examination Council past questions on Set Theory as the main instrument for data collection. A significant difference in favour of those exposed to guided-discovery learning strategy compared to those not taught using guided-discovery learning strategy was revealed in the result.. Therefore, since these relatively new techniques were found to be effective in teaching subject like Mathematics ; it is assumed that they will be effective in teaching science subjects especially Biology, Chemistry, and Physics.

Another study conducted to determine the effectiveness of guided discovery and demonstration teaching techniques in enhancing male and female students' performance in Chemistry[55]. The study adopted a non-equivalent pre-test, posttest control group research design. The results showed that, there was a significant difference in the performance of students exposed to guided discovery, demonstration teaching technique and those exposed to teacher expository teaching technique ($F=123.972$; $p< 0.05$). The findings also showed that, there was a significant difference in the performance of male and female Chemistry students exposed to guided discovery and demonstration teaching techniques ($F= 12.04$ $p< 0.05$). This showed that male and female students performed better when exposed to guided discovery teaching techniques. The post-hoc analysis revealed that, Guided Discovery Teaching Technique (GDTT) had a better significant effect on student academic performance than Demonstration Teaching Technique (DTT) and Teacher Expository Teaching Technique (TETT). The study concluded that, guided discovery teaching technique is a better teaching technique on students' performance in Chemistry than demonstration teaching technique and the teacher expository method respectively.

A study which investigated the effect of Guided Discovery Instructional Strategy (GDIS) on Grade nine learners' performance in chemical reactions and determined the effect of GDIS on gender[56]. A quasi-experimental design with a sample comprising 75 grade nine learners was purposively selected from two schools in Mankweng Circuit based on Grade 12 performance. Learners were randomly assigned to the Experimental Group (EG) (N = 40) and Control Group (CG) (N = 35) taught for two weeks using GDIS for EG and Talk and Chalk Method (TCM) for CG. The results show that there were statistically significant differences in post-test of EG (M = 67.60, SD = 18.70) and CG (M = 37.86, SD = 18.01) (T-test: $t(73) = 6.99$; $p < 0.05$) and a Cohen d = 0.6. EG taught using GDIS outperformed CG taught using TCM (ANCOVA: $F = 15.93$, $p < 0.05$). GDIS favoured both males and females (Mann Whitney U-test: $U = 153.00$, $p = 0.22$, suggesting that GDIS improved all learners' performance in chemistry, but not TCM. The findings provide teachers and stakeholders with empirical evidence on a strategy that improved learners' performance. Also, GDIS did not discriminate against gender, suggesting that the strategy encourages girls to study science, contributing to narrowing the existing gender gap between males and females in Science, Technology, Engineering and Mathematics (STEM) subjects.

Guided Discovery Instructional Strategy (GDIS) is a good teaching strategy for conceptual understanding.

In another study that investigated the relative effects of guided-discovery, student-centered demonstration and expiatory methods of teaching on students' performance in chemistry, with gender as the intervening variable[57]. The results showed that guided-discovery method is the most facilitative, followed by student-centered demonstration; while the conventional expository method, is the least effective. The observed better performances

of the students taught with guided-discovery and student-centered demonstration approaches is attributed to their activity-oriented nature which ensures adequate involvement of the learners in the teaching-learning process. The significantly better effect of guided-discovery over student-centered demonstration is explained in terms of the intrinsic motivation the learners have from their discoveries.

Another study that investigated the effect of guided discovery and lecture methods on students' knowledge retention and achievement in chemistry in tertiary institution[58]. Quasi experimental design of two comparism group method was adopted. A sample of 60 students was randomly drawn from the population of one hundred and twenty four (124) year three tertiary institution students of Department of Chemistry education Imo State University Owerri and Federal College of Education Umunze. The instrument used for data collection was Chemistry Achievement Test which was validated by experts. The reliability of the instrument was determined using Kuder Richardson 21 (Kr-21) correlation method and a reliability coefficient of 0.84 was established for the study. The data generated were analyzed using mean and Analysis of Covariance (ANCOVA). The study concluded that the guided discovery method had more effect on students' academic achievement and level of knowledge retention than lecture method.

Another research on the effect of Guided discovery teaching method on academic achievement and retention in basic science concepts among junior secondary school students found out that there is a significant difference in the academic achievement and retention of students taught basic science concepts using Guided discovery and those taught same concepts using lecture method[59]. He revealed that in Guided discovery method students develop the feeling of working in directive and interaction which always leads to a

considerable degree of discovery, clarity and retention of concepts. He concluded that Guided discovery is a cooperative learning strategy and that the teaching strategy teachers employ in science teaching has significant effects on students' achievement and retention of the learned concepts

2.3.2 Activity-Based Instructional Strategy and Secondary School Students Academic Achievement in Physical Chemistry

The high rates of failure recorded by students in public schools have been a major concern to researchers. Consequently, the poor achievement in chemistry had been traced to conventional strategy that did not put into consideration the students' activity in teaching and learning process. A research work on the effect of activity based teaching strategy on students 'achievement of secondary school students' in chemistry[60]. The moderating effects of gender were also being examined. The study adopted a pretest, posttest, control group, quasi-experimental research design. Five instruments used in the study were: Students Chemistry Achievement Test (SCAT), Instructional guide on Activity based teaching (IGABT), Instructional Guide on Conventional Strategy in Chemistry (IGACSC), Evaluation sheets for assessing teacher performance on the strategies (ESATPS) on Activity based Strategy, and ESAT on Modified Conventional Strategy. Two null hypotheses were tested at 0.05 alpha levels. Data was analyzed using ANCOVA. Treatment had significant effect on subjects' post-test achievement scores ($F_{(2,369)}$=35.248; partial squared =.160). Activity based teaching Strategy was significantly difference from Modified Conventional Strategy in their achievement scores. The result obtained shown that students learn better when they are consciously involved in the teaching and learning process rather than a situation whereby the

teacher is more active in the teaching and learning process than the students. Activity based strategy has proved to be better in enhancing students' achievement in Chemistry possibly due to the nature of the strategy whereby the teacher first explains the concept before the students carry out other processes in the teaching and learning situation. Just as an apprentice first takes instruction from his teacher and follows such in the execution of an assignment, so also in this situation. Nevertheless, this study has proved that the treatment strategy is better than conventional strategy.

Some learners perceive chemistry as a complex subject to learn, saying teaching is boring and not enjoyable. There is a need for making the learning experience more enjoyable to make chemistry easy to understand[61]. Another study aims to assess the effect of activity-based teaching techniques compared to the conventional technique on the performance of students in chemistry[62]. The study was quasi-experimental-based research using both pre and post-test, achievement tests. The sample comprised 166 students, as a total number of students in four classes, from a population of 1610 students of the second grade of secondary classes (SS2) studying the Properties of Organic Compounds and Uses of Alkanes. Pre-test was conducted, and its data was collected before the intervention, and the post-test was conducted and data was collected after the intervention. Both the descriptive and inferential statistical tests were applied in the analysis. Students' performance gain in chemistry was higher in the treatment classes as the mean value was 6.81 and the standard deviation was 1.66 (M = 6.81, SD = 1.66) than that of the comparison classes (M = 6.35, SD = 1.78). But, as far as the gain is higher in treatment classes as compared to comparison classes, there is high confidence that once teachers are supported significantly in the use of activity-based

teaching techniques for an organic chemistry topic, students' performance will be increased significantly.

In a study on effect of hands-on activities on students' achievement in science at elementary stage, the study covered secondary class 6 students of Shiri Kanwartar High School of Khargone district in India[63]. The study used true experimental design. The sample size of 60 students were selected from a population of 113 students through random selection using table of random number and randomly assigning (using lottery) students to two groups of 30 each. The instrument for the study was teacher made achievement test. It consisted of 40 item comprising, fill in the gap, true or false, and marching type questions. An instructional tool which is based on a lesson plan having five steps was used keeping in view the need of the students and activities to be performed for each unit. Data analysis was by the use of descriptive statistics of mean and standard deviation, and inferential statistics with the use of chi-square. Based on the results, it was revealed that the experimental group performed better in science than the control group. The performance of experimental group was better regarding the knowledge, understanding and application based items. There was a significant influence on the achievement of male and female of the experimental group taught through hands-on activity-based. It has some variable in common which is hands-on activity-based and the finding from the study supported the use of hands-on activity based.

Another researcher investigated the relationship of practical work on the achievement of students in Chemistry in Kebbi State[64]. The adopted experimental research design with a sample of 200 SS II students randomly selected from secondary schools in Bunza Local Government Area, Kebbi State. Two instruments, the Chemistry Achievement Test (CAT) and Test of Chemistry Practical Skills (TCPS) were developed and used to collect data for

the study. The students were selected into experimental and control groups comprising of 100 students in each group. The experimental group students were taught using laboratory practical activity while the control group was taught using lecture method. Both groups were exposed to treatment using intact classes for six weeks. Pre and post tests were administered using CAT and TCPS before and at the end of the treatment. The results of the tests were collected, analyzed using Pearson product-moment correlation coefficient. The results of the pretest showed that there was no significant difference in achievement of the two groups. The results of the post-test showed that the students in the experimental group exposed to practical activity performed significantly better than students in the control group who were not exposed to practical activity and also there is no significant difference between the male and female in practical work. The finding of this study relate to the present study as it finds out whether or not, there is relationship between students performance in practical activity work (activity-based) and academic achievements. .

Findings from some other investigators revealed that teaching chemical concept with activity-oriented strategies can impact significantly on students' retention, achievement and understanding[64,]

A research conducted on effect of hands-on activities teaching approach on pupils' achievement in Physic[65]. The study employed a pre-test, post-test non-equivalent quasi-experimental design. Three research questions and three hypotheses guided the study. Intact classes were used for the study. The participants for this study were drawn from six senior secondary schools in Ebonyi State of Nigeria. Three of the schools were assigned to the treatment group while the remaining three were assigned to control group. Physic Achievement Test (PAT) was used for data collection. It consisted of 40 multiple choice

items with four options. PAT questions were drawn from the topics taught during the experiment. The findings revealed that the hands-on activities teaching approach fostered higher achievement in Physic than the conventional method. The review work is similar to the present study is terms of teaching method. However, the present study seeks to find out the effect of activity-based on students' academic achievement in Physical Chemistry.

Findings on the effect of activity-based teaching method on achievement of integrated science students[66]. The study involved 127 Junior Secondary School II students in four classes of Federal University of Technology Staff Secondary School, Akure in Akure Local Government Area, Ondo State. All the four classes were exposed to a 12 weeks teaching period. Three research questions and three hypotheses guided the study. The study used pre-test, post-test quasi experimental design. Three classes were designated to the activity-based group while the fourth was designated to the lecture group. A validated 50- item Integrated Science Achievement Test (ISAT) was the instrument used to collect data. Mean (M) and Standard Deviation (SD) scores were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 levels of significance. The result revealed, among others that, both male and female students' in activity-based group who were allowed to interact and carry out activities in group performed better than those in lecture group who were passive listeners. The activity-based used in this study encouraged student-teacher, students-students, student-material interactions. This study has a basis or implication for the present study though the study was on achievement in integrated science, hence the present study focused on students' achievement in Physical Chemistry.

2.3.3 Gender Difference in Chemistry

Gender has attracted the attention of many psychologists, science educators and other researchers as a result of which a lot of literature exists on different aspects of the concept. For instance, numerous studies have been carried out on gender and social role; gender and work role; gender, science and technology and gender and achievement. In science education generally, there is concern that girls are not achieving as boys [67]. The difference, they said, seem to be more pronounced in the physical science. There are indications at all levels of education in Nigeria that females are grossly under-represented in terms of enrolment, participation and achievement in science, technology and mathematics education.[68]. It was noted that fewer girls take advanced sciences and mathematics courses and elect careers in sciences. Some researchers have advanced some reasons for the difference in gender achievement in science subjects, postulated that sex related differences might be related to social (that is, sex role model and orientation), educational and personal ability. It was discovered that the teachers were friendlier with boys, which created a better rapport for better understanding for the boys. While some studies indicate that in general boys achieve better, or girls outperform boys [63].

A study revealed that there was no significant difference between girls and boys with respect to achievement in life sciences[69], while another researcher reported that boys and girls achieve equally on this standardized measure until the middle school years, when boys begin to have an advantage that lasts through high school, On the other hand, other studies reported that there was a significant gender difference regarding science achievement [70]. For example, the study revealed significant gender differences in chemistry achievement in favor of the boys. Similarly, it was also reported that girls performed at significantly higher levels

on tasks where the content was drawn from the biological sciences and those written tasks assessing science skills. Boys, however, were found to have greater success in the physical sciences. Girls had significantly higher achievement than boys, regarding students' achievement[71]. Therefore, it is of interest to find out if the relationship changes in sex of students could predict their achievement in Physical Chemistry using guided discovery and activity-based as a method of instruction.

2.4 Conceptual Model

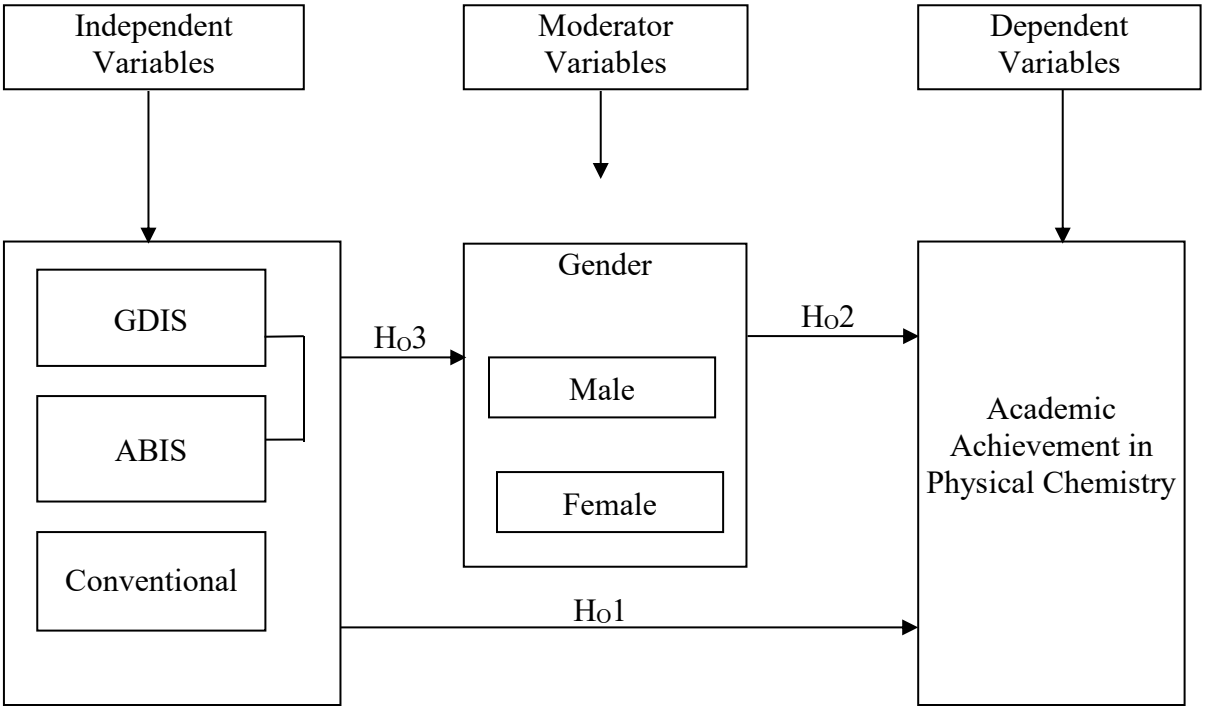

Figure 2.3: Conceptual Model

Source: Researcher, 2024

Conceptual model describes the means that exists among the variables and indicators of the study. The model describes the effects of guided discovery instructional strategy; and activity- based instructional strategy on students' academic achievement in physical chemistry (Topics in Senior Secondary Two) in Lagos West Senatorial District. Students

Academic Achievement in Physical Chemistry was measured by Chemistry Achievement Test.

2.5 Summary of Literature Reviewed

In this study conceptual issues such as students' academic achievement, physical chemistry, guided discovery instructional strategy, activity-based instructional strategy, and gender difference in chemistry were discussed in the context of the study. Achievement of students in chemistry is reported to be generally poor, which attracted the attention of many science educators and researchers. The researcher hoped that guided discovery and activity-based strategies could bring about improve achievement. This study was anchored on two theories which emphasize the fact that use of instructional strategies that are learners-centered in teaching/learning could improve achievement. These theories are Bruner's theory of learning by discovery and Kolb's theory of learning by doing. The theories described the process of learning by the active involvement of the learners in hands-on concrete activities using concrete materials to improve learning experiences and retaining ability of such concept which is in fact the aim of this research work. This research study also considered some empirical studies that are relevant to the present study. The review has shown that learner-centered instructional strategies are necessary for the teaching of some concepts in science. Scarcity of such studies on students' achievement in physical chemistry using guided discovery instructional strategy and activity-based instructional strategy has informed this present study. In the light of this trend of diverse results in the general findings of those studies provided by the review, the present researcher finds it necessary to investigate male and female SSII Chemistry students' achievement in physical chemistry using guided

discovery instructional strategy and activity-based instructional strategy and more so, in Lagos West Senatorial District of Lagos State as a study area.

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Chapter Three

Methodology

This chapter presents the techniques and methods were used in carrying out this research work. It includes research design, population of the study, sample and sampling techniques, description of the research instruments, validity of research instruments, reliability of the research instrument, data collection, method of data analysis and ethical approval.

3.1 Research Design

The study used pretest-posttest control group quasi experimental design.

Table 3.1 Schematic Representation

Group	Pre	Treatment	Post
E_1	O_1	X_1	O_2
E_2	O_3	X_2	O_4
E_3	O_5		O_6

where O_1, O_3, O_5 = Pretest Scores

O_2, O_4, O_6 = Posttest Scores

E_1, E_2, E_3 = Treatment Groups

X_1 = Treatment 1 (Guided Discovery Strategy)

X_2 = Treatment 2 (Activity -based Strategy)

Table 3.2 3x2 Factorial Matrix.

Treatment	Gender	
Guided Discovery Strategy X_1	Male	Female
Activity based Strategy X_2	Male	Female
Control (Conventional Approach) X_3	Male	Female

Source: Field Work 2024

Variables in the Study:

1. Independent variables were manipulated at three levels:

   Guided Discovery Strategy

   Activity based Strategy

   Conventional Strategy.
2. Dependent variable is Academic Achievement
3. Moderating Variables is Gender.

3.2 Population of the Study

The population of this study comprised of all Senior Secondary School II (SS2) Chemistry Students numbering 15,376 in Lagos West Senatorial District. There are three Senatorial Districts in Lagos State, which include Lagos Central, Lagos West and Lagos East. Lagos West was selected out of the three. Three Local Government Areas were randomly selected from Lagos West Senatorial District of Lagos State. The reason for taking Senior Secondary School II Chemistry students was that Physical Chemistry topics are in their curriculum.

3.3 Sample and Sampling Techniques

Multistage sampling procedure was used to select sample for the study. This includes three stages. The purposive sampling technique was used at the first stage to select Senior Secondary School II (SS2) students. The second stage used purposive sampling technique to select schools that are 20 years of existence and above, co-educational, must have completed their Senior Secondary School One Chemistry curriculum at the time of commencement of study, having standard chemistry laboratory and qualified chemistry teacher. The technique is appropriate because it enhances the selection of a true representation (sample) of the target population.

At the third stage, a simple random sampling technique was used to select the three co-educational schools having total number of SS2 science students as 129. 44 from Abesan Senior High School Ipaja, 41 from Lagos State Model College Meiran and 44 from Ikotun Community Senior Grammar School Ikotun. The intact classes in the three schools were randomly assigned as Experimental groups 1 and 2, and the control group, respectively.

Table 3.3: Sample of Senior Secondary two students

Group	School	Gender		
		Male	Female	Total
Group 1	Abesan Senior High School Ipaja, Lagos	23	21	44
Group 2	Lagos State Model College Meiran, Lagos	23	18	41
Group 3	Ikotun Comm Senior Grammer School	23	21	44
	Total	69	60	129

Source: Lagos State Ministry of Basic Education, Research and Statistic Department.

3.4 Research Instruments

The following research instruments were used for the study.

1. Physical Chemistry Achievement Test (PCAT)
2. Teachers Instructional Guide on Guided Discovery Strategy (TIGGDS)
3. Teachers Instructional Guide on Activity-based Strategy (TIGABS)
4. Teachers Instructional Guide on Conventional(Talk and Chalk)Strategy (TIGCS)
5. Evaluation Sheet for Assessing Teachers Performance on the use of ;
    a. Guided Discovery Strategy in Physical Chemistry
    b. Activity-based Strategy in Physical Chemistry
    c. Conventional(Talk and Chalk)Strategy in Physical Chemistry

Physical Chemistry Achievement Test (PCAT)

Physical Chemistry Achievement Test (PCAT) was used to collect data for this study. The PCAT is a researcher made instrument that contains two sections. Section A contains demographic information of the participants, while section B contains 20 multiple choice test items with 4-option (A-D) designed to measure students' achievement in the area of electrolysis to which respondents are expected to provide the correct answer by ticking their choice of response. The content of PCAT is drawn based on the chemistry SS II syllabus. The use of PCAT is to assess students' achievement on what they have been taught. To ensure content validity, the CAT was developed based on the table of specification, there were 10 questions on knowledge, 7 questions on comprehension and 3 questions on application. The basic consideration in developing the table of specification was that objectives may be achieved as stipulated in the curriculum.

Teachers Instructional Guide on Guided Discovery Strategy (TIGGDS)

This instructional guides was a lesson plan prepared by the researcher on the 'concept of electrolysis' and it includes the behavioural objectives of the instruction, instructional procedure and activities in reference to the guided discovery instructional strategy employed in the study. It was used in teaching the experimental group one. The guide provides opportunity for the students to play active roles and be at the centre of the learning process. It is made up of five procedural steps, which include: the introduction, the focus, the observing and recording, the discussion and analysis, then application phases.

Teachers Instructional Guide on Activity-based Strategy (TIGABS)

This instructional guides was prepared by the researcher on the 'concept of electrolysis' and it includes the behavioural objectives of the instruction, instuctional procedure and activities in reference to the activity-bassed instructional strategy employed in the study. It was used for the teaching of experimental group two. In this group students worked in groups. It provides opportunity for the students to play active roles and be at the centre of the learning process. The guide is made up of five procedural steps, which include: the introduction, the focus, the active experimentation, the discussion and application phases.

Teachers Instructional Guide on Conventional (Talk and Chalk) Strategy (TIGCS)

This instructional guides was prepared by the researcher on the 'concept of electrolysis' and it includes the behavioural objectives of the instruction, instructional procedure and activities in reference to the conventional instructional strategy employed in the study. It was used for the teaching of control group. In this group learners worked independently. The guide is

made up of four procedural steps, which include: the introduction, the explanation, listening and writing, the question and answer phases.

Evaluation Sheet for Assessing Teachers Performance on the use of Instructional Strategies

This is the guidelines for evaluating performance of the trained research assistant on the effective use of these strategies: the instrument revealed their presentation of concept, mastery of the topic, use of material and how effective their presentation was for the mastery of the concept by the students using guided discovery strategy, activity-based strategy and conventional (Talk and Chalk) strategy. This is a rating scale that is made up of two sections: section A consist of the personal data of the trained teacher containing name, school, date, time and the concept discussed in the class, section B consist of items that are placed on a two point rating scale yes/no.

3.5 Validity of Research Instruments

The face, content and construct validity of the research instruments was validated by researcher's supervisor and experts in the field to make sure that it measure what it intended to measure. After which, the researcher incorporated the corrections and modifications before the final copy was made.

3.6 Reliability of the Research Instrument

The reliability of the instrument for the study was established through trial testing. Physical Chemistry Achievement Test (PCAT) was administer to a randomly selected 40 SS II students from a senior secondary school which are not part of the schools selected for this

study to establish the reliability coefficient of the PCAT instrument. Kuder–Richardson 20 formula (KR – 20) was used to calculate the reliability coeffient of the instrument and a value of 0.81 was obtained from the exercise.

3.7 Data Collection

The data was collected using a pretest and posttest design. The pretest was administered to both groups before the intervention. The post-test was administered to both groups after the intervention. The tests were designed to assess the students' academic achievement in physical chemistry. The study was conducted over a period of six weeks.

The conduct of the study took place during the normal school lesson periods. The normal time-table of the schools used for the study was followed. Before the commencement of the actual treatment, the researcher trained the chemistry teachers who served as research assistants. The orientation programme covered the following areas:

i) The purpose of the research;

ii) The physical chemistry concepts were taught using the strategies understudy; and

iii) Procedure for administering the instruments.

The orientation programme is to ensure the homogeneity of instructional situation across the groups. The orientation for the experimental groups only differs from that of the control group by the use of guided discovery and activity-based.

Physical Chemistry Achievement Test (PCAT) was administered as pretest by the researcher with the assistance of the sampled schools chemistry teachers. This lasted one week before actual teaching commenced. During lessons, the teachers taught the experimental group electrolysis topics using guided discovery and activity-based in line with lessons procedure

prepared by the researcher. The control group was taught the same electrolysis topics using the talk and chalk method. In all the sampled schools, the actual teaching lasted two weeks of 24 period to cover all the units of electrolysis concepts specified in the table of specification.

At the end of these periods, the pretest was administer as posttest which lasted for one week and the posttest was marked by the research assistants using the marking scheme developed by the researcher.

3.8 Methods of Data Analysis

The data generated from demographic characteristics of the participants was analyzed using percentages, while the null hypothesis was tested at 0.05 level of significance using Analysis of Covariance (ANCOVA). Analysis of Co-variance (ANCOVA) was used for pretest scores which served as covariates so as to take care of the initial differences among the groups.

3.9 Ethical Approval

Ethical approval was obtained from the relevant authorities before the commencement of the study: A letter of introduction was collected from the Head of Department of Science Education, Lead City University Ibadan to collect data from the Lagos State Ministry of Basic Education and the Principals of the sampled schools for permission to conduct the research.

Endnote

Lagos State Ministry of Basic Education. Policy, Planning, Research & Statistic Department, Students Enrolment in Chemistry. June 7, 2024

Chapter Four

Results and Discussion of Findings

The purpose of the study was to determine the effect of guided discovery and activity-based on students academic achievement in physical chemistry. This chapter therefore deals with the presentation of data analysis for the study. This chapter presents results of the analyses and discussion of findings. The results and discussion of findings are presented in tables on the basis of the null hypotheses formulated for the study. The quantitative analysis was analyzed, using analysis of covariance (ANCOVA).. The findings were outlined and discussed accordingly.

4.1 Demographic Data Analysis

The socio-demographic characteristics of the participants were as follows:

Table 4.1: Distribution of the Participants by Gender

Gender	Frequency	Percentage
Male	69	53.5
Female	60	46.5
Total	129	100.0

Source: Field Survey, 2024

Table 4.1 reveals that 69 (53.5%) of the participants were male, while 60 (46.5%) were female. This means that, most of the participants were male.

Table 4.2: Distribution of the Participants by Groups

Treatment Group	Frequency	Percentage
Guided Discovery	44	34.10
Activity-based	41	31.80
Control Group	44	34.10
Total	129	100.0

Source: Field Survey, 2024

Table 4.2 reveals that 44 (34.10%) of the participants were grouped under guided discovery treatment, 41 (31.80%) were grouped under activity-based, and 44 (34.10) were grouped under conventional.

Hypotheses

Main Effects of Treatment (guided discovery, activity-based and conventional instructional strategy) and Gender on Students' Academic Achievement in Physical Chemistry

To determine the main effect of treatment (guided discovery, activity-based and conventional instructional strategy) and gender on Students' Academic Achievement in Physical Chemistry, the data collected were analyzed using one- way analysis of variance (ANCOVA) Consequently, the hypotheses were tested.

$H_0$1: There will be no significant main effect of treatment on senior secondary school students' academic achievement in physical chemistry.

Table 4.3.1: Analysis of Covariance showing the Main Effects of Treatment on Students' Academic Achievement in Physical Chemistry.

Source	TypeIII Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Corrected Model	19109.887	6	3184.981	23.744	.000	.539
Intercept	4057.073	1	40579.073	302.516	.000	.713
Pretest Score (covariate)	138.083	1	138.083	1.092	.312	.008
Treatment	11305.040	2	5652.520	41.139	.000	.409
Error	16364.919	122	134.139			
Total	450275.000	129				
Corrected Total	35474.806	128				

a. R Squared = .539 (Adjusted R Squared = .516)

Table 4.3.1 reveals that f value with degree of freedom (df) (2,122) = 41.139, $p < 0.001$ is significant at 0.00 which is significant at 0.05 $\propto$ level, that is, $F_{(2,122)} = 41.139$, $p < 0.05$ indicating that there is a significant main effect of treatment on academic achievement. Therefore, there was a significant main effect of treatment (guided discovery, activity-based and conventional instructional strategy) on students' academic achievement in physical chemistry. This implies that treatment (guided discovery, activity-based and conventional instructional strategy) were effective on Student academic achievement in physical chemistry. The strength of the effect was estimated using partial eta-square (η^2). Scores at treatment accounted for approximately 40.9% (0.409 from the partial eta square) of the variability in

students' achievement. This indicates that 40.9% difference in students' academic achievement in physical chemistry was due to significant main effect of the treatment.

To determine the magnitude of significant main effect across treatment groups, the estimated marginal means of the treatment groups was carried out and the result is presented in table 4.3.2

Table 4.3.2: Estimated marginal means scores for post- achievement scores between the treatment and control (groups)

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Guided Discovery	60.899[a]	2.044	56.851	64.947
Activity Based	70.826[a]	2.154	66.561	75.092
Conventional	37.813[a]	3.704	30.477	45.149

a. Covariates appearing in the model are evaluated at the following values: PreTest score = 23.1628.

Table 4.3.2 shows that the senior secondary school students exposed to activity-based Strategy, treatment group 2 had the highest adjusted post-test mean score in physical chemistry score (70.826), followed by their counterparts taught with the guided discovery strategy, treatment group 1(60.899) and the conventional (control) group (37.813).

$H_0$2: There will be no significant main effect of gender on senior secondary school students' academic achievement in physical chemistry.

Table 4.4.1- Analysis of Covariance showing the Main Effects of Gender on Students' Academic Achievement in Physical Chemistry.

Source	TypeIII Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Corrected Model	7497.193	3	24499.064	11.165	.000	.539
Intercept	31888.154	1	31888.154	142.472	.000	.713
Pretest Score (covariate)	7195.877	1	7195.877	32.150	.000	.008
Gender	81.487	1	81.487	.364	.547	.003
Error	27977.614	125	223.821			
Total	450275.000	129				
Corrected Total	35474.806	128				

a. R Squared = .539 (Adjusted R Squared = .516)

Table 4.4.1 reveals that f value with degree of freedom (df)(1, 125) =0.364,p= 0.547 is not significant at 0.05 $\propto$ level, that is, $F_{(1,122)}$ =0.364, p >0.05, indicating no significant main effect of gender on difference in post-test scores of students in physical chemistry. The effect size was very low. Therefore, there was no significant main effect of gender on students' academic achievement in physical chemistry. This implies that gender has no effect on student academic achievement in physical chemistry.

To determine the magnitude of significant main effect across the gender group, the estimated marginal means was carried out and the result is presented in table 4.4.2

Estimated Marginal Means

Table 4.4.2: Estimated marginal means scores for post- achievement scores across gender group

			95% Confidence Interval	
Gender	**Mean**	**Std. Error**	**Lower Bound**	**Upper Bound**
Male	55.805	1.805	52.232	59.460
Female	57.664	1.938	53.828	62.427

a. Covariates appearing in the model are evaluated at the following values: Pretest score = 23.1628.

Table 4.4.2 reveals that female students had a higher post test mean score (57.664) than male students (55.805) but the difference was not significant.

$H_0$3 There will be no significant interaction effect of treatment and gender on senior secondary school students' academic achievement in Physical Chemistry.

Table 4.5.1: Analysis of Covariance for Showing the Interaction Effects of Treatments and Gender on Students' Academic Achievement in Physical Chemistry.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	20133.200[a]	11	1830.291	13.958	.000	.568
Intercept	36440.319	1	36440.319	277.906	.000	.704
Treatment* Gender	432.716	2	216.358	1.650	.196	.027
Gender * PretestScore	456.108	1	456.108	3.478	.065	.029
Treatment * Gender * PretestScore	332.654	4	83.164	.634	.639	.021
Instructional Str	2611.169	2	1305.585	9.957	.000	.145
Gender	672.565	1	672.565	5.129	.025	.042
PretestScore	189.724	1	189.724	1.447	.231	.012
Error	15341.606	117	131.125			
Total	450275.000	129				
Corrected Total	35474.806	128				

a. R Squared = .568 (Adjusted R Squared = .527)

Table 4.5.1 reveals that Treatment* Gender: df(2, 117) = 1.650, p = 0.196 , is not significant at 0.05 $\propto$ level, that is,(F =1.650, p >0.05,) indicating no significant interaction effect of treatment and gender. This implies that treatment and gender has no significant interaction effect on students' academic achievement in physical chemistry. Also, the partial eta square value of 0.027 shows the contributing effect size of 2.7%.

To determine the magnitude of significant interaction effect treatment and gender, the estimated marginal means was carried out and the result is presented in Table 4.5.2

Table 4.5.2: Estimated Marginal Means

Gender	Instructional Strategies	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Male	Guided Discovery	56.390[a]	2.884	50.678	62.102
	Activity Based	68.678[a]	3.006	62.726	74.631
	Conventional	40.351[a]	5.048	30.354	50.348
Female	Guided Discovery	65.408[a]	2.897	59.670	71.146
	Activity Based	72.974[a]	3.086	66.863	79.085
	Conventional	35.275[a]	5.423	24.536	46.015

a. Covariates appearing in the model are evaluated at the following values: PreTest score = 23.1628.

Table 4.5.2 shows that female participants in the activity-based treatment group had a higher mean score(72.974) than their male(68.678) counterparts, followed by guided discovery treatment group with female(65.408) and male(56.390) while the conventional control group had the lowest mean score female(35.275) and male(40.351).

4.2 Discussion of Findings

The findings of this study on the demographic characteristics revealed that, most of the participants were males. Also, 34.10% of the participants were exposed to guided discovery instructional strategy, 31.80% in activity-based instructional strategy, while 34.10% participants were in control group.

The findings also revealed that there is a significant main effect of the treatment (guided discovery, activity-based and conventional instructional strategy) on students' academic achievement in physical chemistry. The findings gotten from this study proved that activity-based strategy was more effective in improving students' academic achievement in physical chemistry, followed by guided discovery strategy, then talk and chalk conventional strategy. The effect of activity-based instructional strategy and that of guided discovery instructional strategy may be due to the fact that they are learner-centered, it may also be connected to the fact that the use of these strategies in science teaching orient students towards exploring, engaging, reflecting on, interpreting and searching for solutions to the problems themselves when compared to the conventional strategy. The outcome of this study is in accordance with the outcome of effect of activity based teaching strategy on students 'achievement of secondary school students' in chemistry[1]. Previous study showed that treatment had significant effect on subjects' post-test achievement scores ($F_{(2,369)}$=35.248; partial squared:160). Activity-based teaching strategy was significantly difference from modified conventional strategy in their achievement scores. The result obtained shown that students learn better when they are consciously involved in the teaching and learning process rather than a situation whereby the teacher is more active in the teaching and learning process than the students. Activity-based strategy has proved to be better in enhancing students' achievement in chemistry possibly due to the nature of the strategy whereby the teacher first explains the concept before the students carry out other processes in the teaching and learning situation. Just as an apprentice first takes instruction from his or her teacher and follows such in the execution of an assignment, so also in this situation. The findings from the current study also corroborated with the effect of practical work on the achievement of

students in chemistry; which showed that the students in the experimental group exposed to practical activity performed significantly better than students in the control group who were not exposed to practical activity[2]. Furthermore, the study is also in line with the previous study which investigated the effect of guided discovery instructional strategy (GDIS) on Grade Nine learners' performance in chemical reactions[3]. The results suggest that GDIS improved all learners' performance in chemistry, but not talk and chalk method. Similarly, this study is also in line with investigation on the effect of guided-discovery learning strategy on students' learning outcome in mathematics[4]. A significant difference in favour of those exposed to guided-discovery learning strategy compared to those not taught using guided-discovery learning strategy was revealed in the result.. Therefore, since these relatively new techniques were found to be effective in teaching subject like mathematics; it is assumed that they will be effective in teaching science subjects especially biology, chemistry, and physics.

Another major finding in this study is that there is no significant main effect of gender on students' academic achievement in physical chemistry. Although the female students achieved slightly higher than their male counterparts but ANCOVA test shows that the difference is not significant. This finding agrees with the study who found that there was no significant statistical difference on the achievement of male and female students in chemistry[2]. It is also in accordance with another study which revealed that there was no significant difference between girls and boys with respect to achievement in life sciences[5].

Based on this finding, achievement in physical chemistry is therefore not dependent on gender. This means that the age long disparity in science between male and female students can be laid to rest with the use of appropriate instructional strategy that is learner-

centered. However, the finding contradicts other studies that reported that there was a significant gender difference regarding science achievement[6, 7.]

The finding of this study also revealed that there is no significant interaction effect of treatment and gender on students' academic achievement in Physical Chemistry in Lagos west senatorial district. This implies that treatment effectiveness does not differ significantly and gender does not moderate the impact of treatment on students' academic achievement in physical chemistry. This means that there is no need for separation of instructional method for male and female students since guided discovery and activity-based strategy could be used successfully for the two groups. The outcome of this study lend credence to the submission that different learners with different characteristics may profit more from one type of instructional method than from another and that therefore it may be possible to find the best match of learners' characteristic and instructional method in other to maximize learning outcomes[2]. The current result is also in line with the previous result of effect of guided discovery instructional strategy on Grade Nine learners' performance in chemical reactions and determined the effect of GDIS on gender[3]. The results show that GDIS favoured both males and female, suggesting that GDIS improved all learners'. Finding is also in support of the result of the effect of activity-based teaching method on achievement of integrated science students[8]. The result revealed, among others that, both male and female students' in activity-based group who were allowed to interact and carry out activities in group performed better than those in lecture group who were passive listeners. Although both studies are different in dependent variables, they both examine interaction effect with the same results and limited contextually to the same independent and moderating variables but limited to different geographical locations.

It was further established that the female participants in the treatment group had a higher mean than their male counterparts. This implies that the interaction of treatment and gender had a better effect on academic achievement in physical chemistry among female senior secondary school students than their male counterparts who were exposed to guided discovery and activity-based instructional strategies respectively. In the control group, the male participants had a higher mean score than their female counterparts. This implies that the interaction of treatment and gender had a better effect on academic achievement in physical chemistry among male senior secondary school students than their female counterparts who were exposed to the conventional instructional strategy.

Endnotes

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Chapter Five

Conclusion

This chapter deals with summary of findings, conclusion, recommendations based on the finding of the study, contribution to knowledge and suggestion for further research.

The purpose of this study was to find out if guided discovery and activity-based instructional strategies have effect on students' achievement in physical chemistry among SS II students in Lagos west senatorial district of Lagos State. Specifically, the study examined the effects of guided discovery and activity-based instructional strategies on students' achievement in physical chemistry in three study groups namely; the control and experimental group1 and group 2.

5.1 Summary of Findings

The findings revealed that there is a significant main effect of the treatment **(**guided discovery, activity-based and conventional instructional strategy) on students' academic achievement in physical chemistry. This implies that treatment (guided discovery, activity-based and conventional instructional strategy) were effective on student academic achievement in physical chemistry.

Findings of the study revealed that there is no significant main effect of gender on students' academic achievement in physical chemistry. This implies that gender has no effect on student academic achievement in physical chemistry.

Finding in this study revealed that there is no significant main effect of gender on students' academic achievement in physical chemistry. This implies that treatment and gender has no significant effect on students' academic achievement in physical chemistry.

Finding revealed that there is no significant difference in the academic achievement of male and female students' taught physical chemistry using guided discovery instructional strategy. This implies that both male and female students benefit equally from guided discovery, suggesting that this instructional strategy promotes equity in learning outcomes in physical chemistry.

Finding of this study further establish that there is no significant difference in the academic achievement of male and female students' taught physical chemistry using activity-based instructional strategy. The findings suggest that activity-based strategy is equally effective for both male and female students in achieving academic success in physical chemistry.

5.2 Conclusion

The use of guided discovery strategy and activity-based strategy both enhanced students' achievement in physical chemistry because the two strategies encourage students participation in the classroom since they are student-centered strategies which lead to gain in mean in the physical chemistry achievement test. No gender disparity exists in the achievement of male and female students taught physical chemistry using both strategies. This suggests that both strategies are very rewarding to students' in-terms of achievement regardless of gender.

There is no interaction effect between treatment and gender on students' achievement in physical chemistry. This implies that there is no need for separation of instructional method for male and female since either guided discovery or activity-based could be used successfully.

5.3 Recommendations

In light of the findings, discussion and conclusion drawn from this research, the following recommendations were made:

i. Teachers should be discouraged from using teacher-centered instructional strategy in teaching Chemistry but rather, learner-centered instructional strategies such as guided discovery and activity-based should be used.

ii. Guided discovery and activity-based instructional strategies is not gender sensitive therefore both male and female students should be encourage to cooperate with their teachers when utilized in order to enhance their achievement in Physical Chemistry.

iii. Both strategies require that, there should be standard laboratory and sufficient instructional materials. Schools administrators should provide good laboratory, sufficient instructional materials for students to carry out necessary activities in Physical Chemistry classes.

iv. Workshops, conferences and seminars should be organized by Ministry of Education and other school administrators for Chemistry teachers to introduce and demonstrate innovative instructional strategies in order to enhance students' achievement.

5.4 Contributions to Knowledge

Conceptually, this study has enhanced the conceptual definitions of the following terms, such as the 'effects of guided discovery strategy', 'effects of activity-based strategy',' 'academic achievement' and 'physical chemistry'

This study has contributed to knowledge by providing teachers with an alternative method of teaching physical chemistry effectively as students' achievement was found to be enhanced by the use of guided discovery and activity-based instructional strategies.

This study has also contributed to knowledge by establishing that achievement in science is not gender dependant. Hence, curriculum planner and policy makers in education are enjoined to consider the introduction of guided discovery strategy and activity-based strategy into teaching of physical chemistry as this could narrow the existing gender gap in STEM.

It has also contributed by adding to the existing pool of empirical studies supporting the effectiveness of guided discovery and activity-based instructional strategies in physical chemistry academic achievement.

5.5 Suggested Area for Further Research

Although the current study possesses several findings that are interesting, it is important to consider the limitations of the study as they provide important context in which to understand and qualify the results obtained. The research was limited to selected senior secondary schools in Lagos West Senatorial District, Lagos State which may impede the generalization of the result. Additionally, other unexamined factors, such as students interest, mental ability, learning style teacher expertise and school location could have influenced the results.

Further researches in the field should aim to address some of these shortcomings:

i. Exploring the long-term effects of guided discovery strategy and activity-based strategy on students' academic achievement and retention ability in physical chemistry could also be a valuable avenue for further investigation. This would

provide insights into the lasting impact of this teaching approach on students' learning outcomes.

ii. There is need to replicate the study using some other states to support this study validity.

iii. More investigations need to be carried out on guided discovery strategy and activity-based strategy using other moderating variable like student interest, learning style and school location.

iv. This study can be extended to other concepts in physical chemistry not examined.

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Appendix I

Teacher Instructional Guide for Guided Discovery Strategy

Subject: Chemistry

Lesson Title: Electrolysis

Duration: 80 minutes

Class: SS2

Average Age of Learners: 14 years

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

1 .Define Electrolysis and its principles

2 .Describe the process of electrolysis through guided experimentation

3. Identify common application of Electrolysis

Key Vocabulary: Ionization, discharge, migration, electrode, conductor.

Resource: I.A Odesina (2017) Essential Chemistry for SS. Tonad Publisher Ltd .Lagos. Pg 364-370,

Instructional Materials Electrolysis apparatus including power source, electrodes, beakers and electrolytes solutions, Salt (NaCL,,H_2SO_{4etc}), Safety goggles & gloves, Water, Worksheet with guided questions. - Chart paper and markers

Content Development	**Time**	**Teachers Activity**	**Students Activity**

Step 1 Introduction	10mins	Engage students with a quest; Have you ever wonder how substances can be broken down into their elements.	Respond to the quest
Step 2 a) what electrolysis is b) the parts and functions of an electrolytic cell c) what electrolytes are Electrolysis is the process of using electricity to break down or decompose a compound. Parts of an electrolytic cell; Battery ; • provides electrical energy to drive the chemical reaction • (+) terminal pulls electrons	10mins	Teacher explains ; -what electrolysis is - the parts and functions of an electrolytic cell - what electrolytes are using video.	Students explore the scenario through watching experiments Students explain the phenomena observed

from anode			
Step 3: Guided Experimentation a) electrolysis of aqueous solutions of ionic compounds b) selective discharge of cations c) selective discharge of anions d) selective discharge of anions due to effect of concentration	10mins	Teacher divides students into group 1. Introduce the Electrolysis apparatus and demonstrate setup using a video to emphasize safety precautions. 2. Begin with a simple electrolysis of water.	Students provide an explanation based on the scenario provided.
Step 4: Experimetation Fill beaker with water and add a small amount of salt (NaCl) to increase conductivity Connect battery or power supply to the electrodes (e.g	30mins	Teacher facilitates students' discussion by moving from group to group to listen to their explanation and asking questions to clarify their explanation.	Students carried out experiment based on the instruction given by the teacher Students to explain the

graphite rods or metal wires) - Ask students to observe what happens at each electrode and record their observation - Guide students through questioning : o What gases are produced at each electrode? (H_2@ Cathode, O_2 at Anode) o Why does water split into H_2 and O_2 during electrolysis ? (H_2O Molecules dissociates into H^1 and OH ions, which migrates towards oppositely charged electrodes and reduction/oxidization reactions) o How does flow of electric current affect rate			chemistry behind what was observed Students explain the phenomena observed using a diagram and writing

of electrolysis ? (Higher current increases the rate of electrolysis)			
Step 5: Application	10mins	1. Discuss practical applications of electrolysis in various industries and modern technology. 2. Encourage students to brainstorm other substances that can be electrolyzed and their potential applications.	Students to brainstorm other substances that can be electrolyzed and their potential applications .
Step 6: Summary and conclusion	5mins	1. Summarize key concepts learned during the lesson. 2. Encouraged students to reflect on the importance of Electrolysis in everyday	Students reflect on the importance of Electrolysis in everyday life and in the advancement of technology and give their response.

		life and in the advancement of technology.	
Step 7: Evaluation	5mins	Teacher evaluate the students based on the lesson	Students attempt the concept test given in the evaluation.

Appendix II

Teacher Instructional Guide For Activity-based Strategy

Subject: Chemistry

Lesson Title: Electrolysis

Duration: 80 minutes

Class: SS2

Average Age of Learners: 14 years

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

1. Define the concept of electrolysis and its applications.

2. Demonstrate the process of electrolysis through hands-on activities.

3. Analyze and discuss the results of their experiments.

4. Identify common application of Electrolysis

Key Vocabulary: Ionization, discharge, migration, electrode, conductor.

Resource: I.A Odesina (2017) Essential Chemistry for SS. Tonad Publisher Ltd .Lagos. Pg 364-370 ,

Instructional Materials: Electrolysis apparatus including power source, electrodes, beakers and electrolytes solutions, Salt (NaCL,,H_2SO_{4etc}), Safety goggles & gloves, Water, Worksheet with guided questions. - Chart paper and markers

Presentation

Step 1: Introduction (10 minutes):

Teachers Activity

1. Begin the lesson by asking students if they have heard about electrolysis and what they understand by it.

2. Introduce the concept of electrolysis, explaining key terms such as electrolyte, electrodes, cathode, and anode by setting a up an electrolytic cell.

Students Activity

1 .Students responds to the question on what they know about electrolysis

2. Students observe and later set the cell on their own.

Step 2: Electrolysis of Water (30 minutes):

Teachers Activity

1. Divide students into small groups and provide safety instructions.

2. Guide students through the process of electrolysis of water

Students Activity

Each group set up stations with electrolysis apparatus

- Fill a beaker with water and add a small amount of salt (NaCl) to increase conductivity (optional).

- Connect the battery or power supply to the electrodes.

-Students to observe and record their observations as the electrolysis proceeds.

- Discuss their observations and brainstorm explanations for the observed phenomena.

Step 3: Electroplating Demonstration (20 minutes):

Teachers Activity

Explain the process of electroplating and its applications, such as coating metal objects with a layer of another metal for protection or aesthetics.

Students Activity

1. Students ask questions and discuss the principles behind electroplating.
2. Conduct a demonstration of electroplating using a simple setup.
3. Use chart paper to create a visual representation of the electrolysis process, highlighting key concepts and reactions.

Step 4: Discussion and Analysis (15 minutes):

Teachers Activity

Reconvene as a class and facilitate a discussion based on students' observations and experiences during the activities.

Students Activity

Students to analyze the results of their experiments and draw conclusions about the process of electrolysis.

Step 5: Summary and Conclusion (5 minutes):

1. Summarize the main points covered during the lesson, emphasizing the importance of electrolysis in various industries and technologies.

2. Encourage students to reflect on what they have learned and how it relates to their everyday lives.

3. Assign a follow-up activity, such as researching a specific application of electrolysis and its impact on society.

Step 6: Evaluation

1. describe electrolysis as the conduction of electricity by an ionic compound (an electrolyte), when molten or dissolved in water, leading to the decomposition of the electrolyte

2. describe, in terms of the mobility of ions present and the electrode products, the electrolysis of molten sodium chloride, using inert electrode

3. predict the likely products of the electrolysis of an aqueous electrolyte, given relevant information.

4. describe the electroplating of metals, e.g. copper plating, and state one use of electroplating .

Appendix III

Teacher Instructional Guide for Conventional Strategy

Subject: Chemistry

Lesson Title: Electrolysis

Duration: 80 minutes

Class: SS2

Average Age of Learners: 14 years

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

1. Define electrolysis.
2. Define terms used in electrolysis.
3. Understand the process of electrolysis
4. Mention application of electrolysis.
5. State the product of electrolysis of H_2SO_4.

Key Vocabulary: dissociation, migration.

Resource: I.A Odesina (2017) Essential Chemistry for SS 2. Tonad Publisher Ltd .Lagos. Pg 364 ,

Instructional Materials Electrolysis apparatus including power source, electrodes, beakers and electrolytes solutions, Salt ($NaCL$,$H_2SO_{4\ etc}$), Safety goggles & gloves, Water, Worksheet with guided questions. - Chart paper and markers

Building Background/Connection to Prior Knowledge: students are familiar with electric current.

Presentation

Step 1: Introduction

Teacher introduces the lesson using flow of electric current, while students listen attentively to the teacher

Step 2: Explanation and Discussion

Teacher describes the electrolysis of H_2SO_4 using the mechanism of electrolysis and identify the ions deposited at the electrode .

Step 3: Writing of note

Students write down the board summary in their note.

Step 4: Question and Answer

The teacher solicits questions from students and give class work.

Step 5: Summary and Conclusion (5 minutes):

Summarize the main points covered during the lesson, emphasizing the importance of electrolysis in various industries and technologies.

Step 6: Evaluation

The teacher marks the note, evaluate and give assignment.

1. .what is electrolysis.
2. Define terms ; electrolytes, electrode and conductor
3. Describe process of electrolysis of brine.
4. Mention 3 application of electrolysis.
5. State the product of electrolysis of H_2SO_4.

Appendix IV

Chemistry Achievement Test (CAT)

Section A : Demographic Characteristics of Participant

Please fill these appropriately

School Name ----------

Gender male ( ) female ( )

Section B

Instruction: Circle only the correct answer from the options A -- D

1. In the electrolysis of water, what gas is produced at the cathode?
A. Hydrogen gas
B. Oxygen gas
C. Chlorine gas
D. Neon gas

2. Which electrode attracts sodium ions during the electrolysis of molten sodium chloride?
A. Anode
B. Cathode
C. Electrode
D. Election

3. What is the purpose of adding an electrolyte to water before electrolysis?
A. To increase the electrical conductivity of the solution
B. To decrease the electrical conductivity of the solution
C. To produce more hydrogen gas
D. To produce more oxygen gas.

4. Which of the following substances is not a common electrolyte used in electrolysis?
A. NaCl
B. H_2SO_4
C. $C_6H_{12}O_6$
D. NaCl(aq)

5. In the electrolysis of aqueous sodium chloride, what gas is produced at the anode?
A. Hydrogen gas
B. Oxygen gas
C. Chlorine gas
D. Fluorine gas

6. Which of the following occurs at the cathode when a solution of $CuSO_4$ is electrolyzed using copper electrode ?
A. cathode gains mass of copper
B. blue color fades gradually
C. both electrode gain electron
D. anode increases in mass

7. Electrical current used in electrolysis is typically measured in?
A. Volt
B. Ohms
C. Mass
D. Amperes (A)

8. What is the chemical symbol for the hydroxide ion?
A. Cl^-
B. OH^-
C. H^+
D. O^{2-}

9. Which of the following is an example of an inert electrode?
A. Cupper
B. Sulphur
C. Graphite
D. Platinum

10. What ions migrate towards the cathode during the electrolysis of water?
A. Oxygen ions
B. Chloride ions
C. Hydrogen ions
D. Hydroxide ions

11. Which law of electrolysis states that the amount of a substance produced during electrolysis is directly proportional to the quantity of electricity passed through the electrolyte?
A. Faraday's second law of electrolysis.
B. Faraday's first law of electrolysis
C. Law of conservation of mass
D. Graham's law.

12. In the electrolysis of brine (sodium chloride solution), what other compound besides chlorine gas is produced at the anode?
A. Hydrogen gas
B. Oxygen gas
C. Chlorine gas
D. Argon gas

13. What type of reaction occurs at the anode during electrolysis?
A. Decomposition
B. Reduction
C. Oxidation
D. Redox

14. What is the process called when an ionic compound is broken down into its elements by passing an electric current through it?
A. Electrolysis
B. Conductivity
C .Migration
D. Ionization

15. Which of the following metals is not obtained by electrolysis of its molten ore?
A. Aluminum
B. Sodium
C. Lead
D. Iron

16. What is the overall reaction occurring at the cathode during the electrolysis of water?
A. $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$
B. $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
C. $2H^+(aq) + 2e^- \rightarrow H_2(g)$
D. $2H_2O(l) \rightarrow 2OH^-(aq) + 2H^+(aq) + O_2(g)$

17. What is the function of the salt bridge in an electrochemical cell?
A. Divides the cell
B. Allow mixing of electrolytes
C. It completes the circuit and maintains electrical neutrality
D. It serves as brigde between cells

18. Electrolysis can be apply in the following processes except
A. Extraction of irons
B. Electroplating
C. Galvanizing
D. Production of substances

19. In the electrolysis of dilute sulfuric acid, what gas is produced at the anode?
A. Nitrogen gas
B. Oxygen gas
C .Hydrogen gas
D. Sulphur gas

20. What is the purpose of adding a salt to water before electrolysis?
A. To increase the electrical conductivity of the solution
B. To decrease the electrical conductivity of the solution

C. To produce more hydrogen gas
D. To produce more oxygen gas

Answer

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

Appendix V

Evaluation Sheet for Assessing Teachers' Performance on Guided Discovery Instructional Strategy

Section A: General Information

- Observer Name:

- Date of Observation:

- Class/Grade Level:

- Subject: Physical Chemistry

- Teacher's Name:

- Start Time:

- End Time:

Section B: Performance Evaluation on Effectiveness of GDIS

This checklist will help systematically observe and record the use of Guide Discovery Strategy in a Physical Chemistry class, ensuring comprehensive data collection for your research.

S/N	Item Observed	Comments (Yes/No)	
		Yes	No
1	Teacher encourages students to explore new concepts on their own.		
2	Students are provided with open-ended problems to solve.		
3	Teacher provides hints and clues rather than direct answers.		
4	Students learn through trial and error.		
5	Classroom environment supports independent thinking.		
6	Students ask questions and seek answers themselves.		
7	Teacher acts as a facilitator rather than a lecturer.		
8	Learning activities promote discovery and exploration.		
9	Students work on projects requiring problem-solving.		
10	Teacher uses real-life examples to stimulate curiosity.		

Appendix VI

Evaluation Sheet for Assessing Teachers' Performance on Activity-Based Strategy

Section A: General Information

- Observer Name:

- Date of Observation:

- Class/Grade Level:

- Subject: Physical Chemistry

- Teacher's Name:

- Start Time:

- End Time:

Section B: Performance Evaluation on Effectiveness of ABIS

This checklist will help systematically observe and record the use of Activity Based Strategy in a Physical Chemistry class, ensuring comprehensive data collection for your research.

S/N	Item Observed	Comments (Yes/No)	
		Yes	No
1	Teacher incorporates hands-on activities.		
2	Students engage in experiments and practical tasks.		
3	Classroom is equipped with materials for interactive learning.		
4	Learning activities connect to real-world scenarios.		
5	Students participate in group activities.		
6	Teacher uses simulations and role-playing.		
7	Students create models or prototypes.		
8	Lessons involve outdoor or field activities.		
9	Teacher provides opportunities for project-based learning.		
10	Students use manipulatives to understand concepts.		

Appendix VII

Evaluation Sheet for Assessing Teachers' Performance on Conventional Strategy

Section A: General Information

- Observer Name:

- Date of Observation:

- Class/Grade Level:

- Subject: Physical Chemistry

- Teacher's Name:

- Start Time:

- End Time:

Section B: Performance Evaluation on Effectiveness of CIS

This checklist will help systematically observe and record the use of Conventional Strategy in a Physical Chemistry class, ensuring comprehensive data collection for your research.

S/N	Item Observed	Comments (Yes/No)	
		Yes	No
1	Teacher uses lectures to deliver content.		
2	Students take notes during lessons.		
3	Classroom layout supports teacher-centered approach.		
4	Teacher uses textbooks as the main source of information.		
5	Students are given structured assignments.		
6	Teacher controls the pace of the lesson.		
7	Teacher provides direct instruction and explanations.		
8	Classroom discussions are limited and controlled by the teacher.		
9	Students are assessed through written exams and quizzes.		
10	Teacher uses blackboard or whiteboard frequently.		

Appendix VIII

Table 3. 3: Specification for CAT

S/N	Concepts	Knowledge	Comprehension	Application	Total No. of Items
	Electrolysis	**1,3,5,8,2**	**12,14, 15,20**	**10**	**10**
	Ionic theory	**19**	**13,16**	**6**	**4**
	Electrolytes & non electrolytes	**4,9**			**2**
	Laws of electrolysis		**11**		**1**
	Application & Practical	**7,18**		**17**	**3**
	Total	**10**	**7**	**3**	**20**

Bio-data

A. Personal Data

Name in full : Grace Olubukola OLANREWAJU

Address: 12, Living proof Street, Obasanjo, Ota Ogun State

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Marital Status: Married

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Phone No: +234 8057447536

Date of Birth: 4th Sept 1981

Name of Next of Kin: Ogunleke Samuel OLANREWAJU

Address of Next of Kin: 12, Living proof Street, Obasanjo, Ota Ogun State

B Educational Background

	Educational Institution Attended	**Qualification**	**Year**
i	St. Paul's Anglican Primary School Ishagatedo , Isolo	School Leaving Cert.	1992
ii	Okota Secondary School, Okota, Isolo	SSCE	1998
iii	Adeniran Ogunsanya College of Education , Lagos	NCE	2002
iv	University of Nigeria, Nsukka, Enugu State	BSc (ED) Chemistry	2007
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Signature	**Date**

The University Compliance Certification

This is to certify that this Thesis by Grace Olubukola OLANREWAJU in the Department of Science Education, Faculty of Education, Lead City University, Ibadan Oyo State is in full compliance with the approval University Format and Style

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Signature **Date**