EFFECTS OF ASEI-PDSI INSTRUCTIONAL STRATEGY ON SENIOR SCHOOL STUDENTS' ACHIEVEMENT, SELF-EFFICACY AND ATTITUDE TOWARDS CHEMISTRY IN ILORIN, NIGERIA

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DEDICATION

To my dear parents, late Mallam Idris Olokonla Muhammed, Alhaja Maryam T. Muhammed and my dearest husband, Mr. Omotosho Lukman Ibrahim.

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All praise and adorations to ALLAH, the living and the self-subsisting. He who in his infinite mercies, granted me the opportunity, knowledge and strength to accomplish this self-responsibility. Indeed, only Him is worthy of worship. Also, to the holy Prophet Muhammad (S A W) and the entire Muslim community in the world.

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Abstract

Chemistry, to a great extent has contributed to the survival of human kind. This is evidenced in such areas as medicine, engineering, agriculture, and transportation. However, the teaching and learning of Chemistry is confronted with myriad of challenges such as under-achievement, low self-efficacy and negative attitude. The Activity, Student-centered, Experiment, Improvisation-Plan, Do, See, Improve (ASEI-PDSI) instructional strategy is a pedagogical model for Strengthening Mathematics and Science Education, and thought to be an intervention measure to these challenges. Hence, this study investigated the effects of ASEI-PDSI instructional strategy on Senior School students' achievement, self-efficacy, and attitude towards Chemistry. The objectives of the study were to examine the: (i) difference in achievement, self-efficacy, and attitude of students exposed to ASEI-PDSI instructional strategy and conventional method; (ii) influence of gender and score levels on students' achievement in Chemistry; and (iii) interaction effects of treatment with gender and score levels on students' achievement in Chemistry.

The study adopted a quasi-experimental, non-randomized, pretest, posttest, control group design. The population was all the 40,379 Senior School students offering Chemistry in Ilorin, Nigeria, while the target population was 13,460 Senior School I (SSI) students offering Chemistry. The sample comprised 292 SSI students from four randomly selected co-educational schools in Ilorin, Nigeria. The ASEI-Instructional Package (ASEI-IP) was the stimulus instrument; the Acids, Bases and Salts Achievement Test (ABSAT), Attitude Towards Chemistry Scale (ATCS), and Chemistry Self Efficacy Scale (CSES) were the test instruments. The reliability coefficients of ABSAT, ATCS and CSES were found to be 0.76, 0.68 and 0.73, respectively. The data gathered were analysed using Analysis of Covariance and *t*-test statistic.

The findings of the study were that:

i. a significant difference existed in the achievement of students exposed to ASEI-PDSI instructional strategy (experimental) and those not exposed to ASEI-PDSI instructional strategy (control), ($M_{(\text{experimental})} = 25.03 > M_{(\text{control})} = 11.02$; $F_{(1,\ 289)} = 238.24$, $p < .05$);
ii. a significant difference existed in the self-efficacy of students exposed to ASEI-PDSI instructional strategy (experimental) and those not exposed to ASEI-PDSI instructional strategy (control), (($M_{(\text{experimental})} = 28.68 > M_{(\text{control})} = 25.79$; $F_{(1,\ 289)} = 15.32$, $p < .05$);
iii. there was no significant difference in the attitude of students exposed to ASEI-PDSI instructional strategy (experimental) and those not exposed to ASEI-PDSI instructional strategy (control);
iv. there was no significant difference in the achievement of male and female students exposed to ASEI-PDSI instructional strategy;
v. a significant difference existed in the achievement of low, medium and high scorers exposed to ASEI-PDSI instructional strategy, ($M_{(\text{high})} = 27.85 > M_{(\text{medium})} = 24.70 > M_{(\text{low})} = 23.61$; $F_{(2,\ 149)} = 5.90$, $p < .05$); and
vi. there was no significant interaction effects of treatment with gender and score levels on students' achievement in Chemistry.

The study concluded that ASEI-PDSI instructional strategy improved students' achievement, self-efficacy and attitude towards Chemistry. This implies that, ASEI-PDSI instructional strategy is very effective for teaching and learning of Chemistry. The study recommended that teachers should adopt ASEI-PDSI instructional strategy to teach Chemistry, especially at the Senior School levels.

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CHAPTER ONE

INTRODUCTION

Background to the Problem

The basis for ranking nations of the world as developed, developing, and under-developed is by measure of their scientific and technological advancement. Hence, the importance of science and technology to national development cannot be over-emphasized. For Nigeria to move away from consumer of technology and become scientifically and technologically inclined, it is imperative for her to strengthen science education, as the knowledge of science is a requirement to attain this state.

Science is a way of helping our brain grow in finding new knowledge and help to defeat our curiosity of how the world develops and works. Different scholars have different views on how science should be defined. Science is seen as something that generates knowledge through observations, data, concepts, diagrams, theories and so on (Ziman, 2009). Similarly, Abimbola (2013), viewed science as an enterprise in which human beings participate to study and give parsimonious explanations of the materials and forces of nature. Thus, science can be viewed as any human's ability to explore his environment.

Science, to a great extent has contributed to the survival of human as scientific knowledge, product of technology, skills and artifacts invade all realms of life in this modern society. This is evidenced in medicine, engineering and technology, transportation, banking and finance and most importantly, education. The study of science has an educative influence on the mind and is of far- reaching importance. Today, scientists speak of the wonder of nature with a thrill of emotion. Thus, the curriculum should extend the study of science to all levels of education because, the modern man needs a scientific mind in approaching the problems of life.

Learning science involved not only with its contents, but also with its methodology. The field of science education caters for both. Science education is the field of science that is concerned with sharing of science contents and the process of teaching science pedagogy in order to cultivate curiosity in learners and promote scientific thinking for the development (Bybee & Powell, 2008). The goals of science education as stated by Bybee and Powell (2008) include that science education should:

i. Develop fundamental understandings of natural systems;
ii. develop fundamental understanding of, and ability to use the methods of scientific inquiry;
iii. prepare learners to make responsible decisions concerning science related issues;
iv. prepare learners on how to fulfil personal needs and thus, contributing to personal development; and
v. inform learners about careers in science.

Science as an interdisciplinary course of study, comprises of different subjects such as Biology, Chemistry, Agriculture, Physics, Computer, Engineering and others. Chemistry is the study of matter, its composition, the combination/separation of substances to form other substances, and their interactions with energy (Bagley, 2017). Chemistry is therefore, the study of physical and chemical composition of matter. Chemistry is sometimes called the central science because it bridges the gap between other natural sciences, including physics, geology and biology (Adebayo, 2008; Brown, 1999).

There are four main branches of chemistry, each with wider areas of study: the analytical chemistry, that uses qualitative and quantitative observation to identify and measure the physical properties of substances; the physical chemistry combines chemistry with physics to study the interactions between matter and energy; the organic chemistry studies carbon compounds; and the inorganic chemistry studies metals and gases.

The fields of study in chemistry include food chemistry, environmental chemistry, agricultural chemistry, chemical engineering, geochemistry, forensic chemistry and so on. Thus, the importance of chemistry is obvious in all aspect of human endeavors. In spite of these importance, students' achievement in Senior School Chemistry Certificate Examinations over the years is still not impressive, as shown in Table 1.

From Table 1, the trends indicate steady increase in candidates' enrolment in West Africa Senior School Certificate Examination (WASSCE) science subjects except in 2017 where there was decrease. However, the progressive enrolment returns in the years 2018 and 2019. This serves as good news and perhaps, a cause of concern to stakeholders in education. Despite the revolutionary hike in enrolment, the percentage credit pass in all these sciences is still not good enough for a developing country like Nigeria. Less than two-third of the total enrolment in the years under review made it to credit pass except in 2013, 2017 and 2019 where the percentage passes were 72.35, 84.83 and 77.96 respectively in chemistry. Specifically, in chemistry, a haphazard trend in achievement was noted, for instance, from 2007 to 2012, low achievement was observed while in 2013, a commendable one was recorded. However, this incredible achievement dropped to 57.74% in 2016, upturned in 2017, declined in 2018 and rose again in 2019. Hence, one can infer that future achievement cannot be accurately predicted.

Table 1

Candidates' Enrolment and Performance in May/June Senior School Certificate Examinations in Biology, Chemistry and Physics in Nigeria 2007-2016

Year	Biology			Chemistry			Physics		
	TOTAL SAT	Credit passed (AI-C6)	%PASS	TOTAL SAT	Credit passed (AI-C6)	%PASS	TOTAL SAT	Credit passed (AI-C6)	%PASS
2007	1,238,163	413,211	33.37	424,747	196,063	46.16	409,449	180,797	44.16
2008	1,259,964	427,644	33.94	456,980	202,762	44.37	408,237	200,345	49.08
2009	1,259,964	453,928	33.87	456,980	203,365	43.49	444,236	222,722	50.14
2010	1,300,418	427,644	32.88	465,643	263,059	50.70	463,755	237,756	51.27
2011	1,505,199	579,432	38.50	565,692	280,280	49.54	563,161	360,096	63.94
2012	1,646,150	587,044	35.66	627,302	270,570	43.13	624,658	429,415	68.74
2013	1,648,363	852,717	51.73	639,296	462,517	72.34	637,023	297,988	46.77
2014	1,365,384	766,971	56.17	636,268	397,649	62.49	635,729	386,270	60.76
2015	1,390,234	798,246	57.42	680,357	412,323	60.60	684,124	410,543	60.01
2016	1,200,367	740,345	61.68	706,873	408,122	57.74	705,125	415,655	58.95
2017	580,449	394,898	68.30	377,970	320,635	84.83	377,851	205,757	54.45
2018	1,087,063	679,299	62.48	728,551	424,231	58.22	728,354	571,687	78.49
2019	1,033,304	775,103	75.01	726,132	566,156	77.96	725,853	565,746	77.94

Source: West African Examinations Council, 2020.

Over time, several studies have been conducted on factors responsible for students' under-achievement in science subjects. Ngeme (2016), Odhiambo (2016), Strengthening Mathematics and Science Education, (SMASE) baseline survey of 2006 in separate studies stressed teachers' misconceptions, poor knowledge of subject matter, poor classroom organization by teachers, and inappropriate teaching methodologies as factors responsible for students' under-achievement in science.

Similarly, the West Africa Examinations Council, WAEC Chief Examiner's report of 2013-2018 in chemistry reported: students' lack of understanding of important chemistry principles such as stoichiometry; poor interpretation of questions; inability to assign correct charges to anions and cations; poor expression and use of non-chemical terms; inability to apply theoretical knowledge to practical examination; inability to relate chemistry concepts to immediate environment; poor knowledge of oxidation/reduction reactions; evidence of lack of laboratory experiences; poor knowledge and inability to correctly solve calculations on solubility; and inability to write chemical formula correctly and balance chemical equations. These prevalent weaknesses could have contributed immensely to their under-achievement.

One can deduce from the Chief Examiners' report that students' poor knowledge of chemistry concepts, theories and principle may be linked to their poor knowledge and alternative conceptions of acid-base chemistry, as acid-base chemistry is fundamental to the study and understanding chemistry as a subject (Okam & Zakari, 2017). Similarly, Lin and Chiu (2007), Sheppard (2006) earlier posited that the concept of acids and bases have connections with other concepts in chemistry such as solutions, concentration, oxidation/reduction, and chemical equilibrium and that, understanding acid-base chemistry requires comprehension of many areas of introductory chemistry including chemical reactions, stoichiometry, the nature of matter and solutions.

Several researchers have contributed towards understanding of key ideas about acids and bases and the need for further studies (Ultay & Calick, 2016). Apart from it interwoven link with everyday phenomena, acid-base chemistry is an important and fundamental concept in chemistry that covers primary, secondary, pre-service education, in-service education and postgraduate education (Lin & Chiu, 2007; Tarhan & Sesen, 2012; Ultay & Calick, 2016).

In addition, studies have consistently reported that students hold alternative conception in acid-base chemistry (Artdey, Ratanaroutai, Coll, & Thongpanchang, 2010; Drechsle & Schimidit, 2005; Furio-Mas, Calatayud, & Barcenas, 2007). Hence, the need to teach acid-base chemistry with an instructional strategy that is student-centered and activity-oriented such as the ASEI-PDSI instructional strategy which has been used and confirmed to be effective in improving students' learning and understanding of concepts is imperative.

This instructional strategy, Activity, Student-centered, Experiment and Improvisation (ASEI), is home-grown strategy that promote learner-centered and activity-based learning among students through active knowledge construction based on their real-life experiences and understanding. It was an initiative of the Nigeria government through the Federal Ministry of Education (FME) in collaboration with the Japan International Corporation Agency (JICA) in 2006 in an attempt to make teaching/learning of science and mathematics more student-centered, activity-based and experiential through capacity building of science and mathematics teachers entitled Strengthening Mathematics and Science Education (SMASE).

The choice of JICA was born out of the several successes of its collaboration in instituting, organizing, and executing sustainable and qualitative in-service training programmes for mathematics and science teachers in many African countries such as Kenya, Ghana, Uganda, Malawi, Egypt and so on (SMASE, 2010). The SMASE Nigeria emanated from the Association for the Development of Education in Africa, ADEA's mandate to promote education in Africa and to strengthen mathematics and science through Continental Programme for Strengthening Mathematics and Science.

However, in order to enhance ownership and country-level implementation of the programmes by participating countries, each country has different title based on their

educational needs for it country-based capacity building. For instance, in Kenya, the programme is tagged Strengthening Mathematics and Senior Science Education (SMASSE); Strengthening Mathematics, Science and Technology Education (SMASTE), in the case of Zambia; in Ethopia, it is Strengthening Mathematics and Science Education in Ethopia (SMASEE) and so on.

In 2006, a pilot study was carried out by FME and JICA to ascertain the strategies in use, the needs and challenges facing teaching and learning of science and mathematics in Nigeria, and to examine the effects of ASEI-PDSI instructional strategy on students' learning. The findings of the study indicated that: science and mathematics were taught with monotonous use of lecture method; poor teacher-learner strategy also noted; perceived difficult science and mathematics concepts by teachers and learners; and that pupils taught using ASEI-PDSI instructional strategy performed significantly better than those taught without ASEI-PDSI.

The objectives of ASEI-PDSI as stated by Strengthening Mathematics and Science Education (SMASE Nigeria) were to enhance teaching and learning of mathematics and science through active learners' participation in classroom activities; improve teachers' performance in subject mastery, pedagogical skill and resource utilization; and develop positive teachers' and students' attitudinal change towards teaching and learning of mathematics and science. The ASEI-PDSI instructional strategy, embodies efforts to encourage a paradigm shift from chalk and talk approach to activity/student-centered approach (Mwelese & Awoto, 2014).

The four principles which form the basis for the ASEI pedagogical paradigm as shown in Figure 1, are:

i. Activity-oriented teaching: carefully selected activities that would enhance students' participation, interest, understanding and retention of knowledge;

ii. student-focused learning: active students' involvement in teaching/learning process where the teacher guides and gives students opportunity to express opinions, explain ideas based on their prior experiences and verify their opinions through suitably designed activities;

iii. experiment/research based approach: scaled down, investigative experiments which are simpler, more relevant to specific lesson objectives, and enable students to discover, reinforce new concepts, rather than those prescribed in textbooks;

iv. improvisation: teachers' innovativeness in designing simple experiments to enhance students' interest, participation and learning; drawing from locally available resources and students' real life experiences.

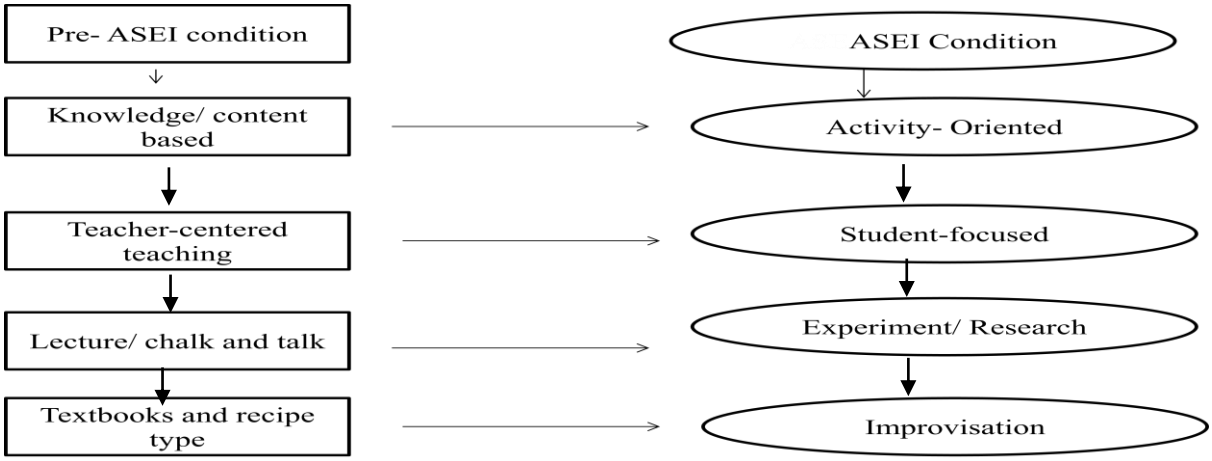


Figure 1*: The Principles of ASEI Paradigm Shift (SMASE, 2010)*

The PDSI stands for Plan; Do; See; and Improve. This is the means through which ASEI is achieved. *Plan* is the actual preparation of the lesson. Here, the teacher identifies the lesson objectives, select materials and appropriate activities which should be well thought-out. The ASEI lesson plan through PDSI should contain introduction, content, consolidation, achievement of objectives, students' involvement and classroom management.

Do refers to the actual teaching or implementation of the planned lesson in the classroom. The introduction of the lesson is expected to arouse the students' interest and curiosity, the teacher should make use of the students' ideas and knowledge and they should be assisted to bridge the activities to the concepts being taught, also, at all times the students should be the centre of the lesson.

See, involves evaluating the lesson as it progresses by the teacher or colleagues for the sake of improvement. Evaluation by students and/or colleagues may take many forms such as responding to a written questionnaires or verbal feedback or free card analysis. From the comments made or given or the teacher's own evaluation, the teacher is expected to incorporate the changes in future similar lesson and hence makes necessary improvement (Improve).

For a lesson to attain an ASEI status, the teacher plans, implements, observes and improves on the subsequent lessons (PDSI). Thus, the premise of SMASE Nigeria centers on extensive and conscious planning of the lesson for better classroom implementation. Lesson planning is an integral phase of teaching. As such, it gives the teacher greater assurance and greater freedom in teaching, provides adequate lesson summaries and most importantly, saves teacher from haphazard teaching (Mallick, 2012).

The ASEI lesson planning requires the teacher to develop a lesson plan, interaction plan and chalkboard plan for every lesson. The ASEI lesson plan isn't different from what teachers are used to, however, variables like, rationale and learning points are introduced into this plan. The assumption is that all topics to be taught to students should be justified; and that, at every step of lesson delivery, the teacher should indicate the objective he seeks to achieve at that level and the procedures he employs in achieving the main objective(s) of the lesson (SMASE, 2010).

Similarly, for effective classroom learning to take place, there is need for interaction among teacher, learners and learning materials. Hence, interaction plan is a plan that shows the strategies a teacher seeks to employ in order to control the quality of learning outcomes (SMASE, 2018). Classroom communication involves different interaction patterns, which among others are: student to student (pair work); student to the class; group work; student to teacher; teacher to students; and teacher to individual student.

In addition to interaction plan, it is crucial to plan for what is to be written on the chalkboard. This enables the teacher to clarify the points of the lesson and to reinforce the logical flow of the lesson. Chalkboard plan also allows the students to see the sequence of activities to reach the lesson objective(s) and serves as road map to reach the conclusion (SMASE, 2018). Hence, the ASEI-PDSI instructional strategy emphasizes and centralizes lesson planning, where other components emerge from it, as shown in Figure 2.

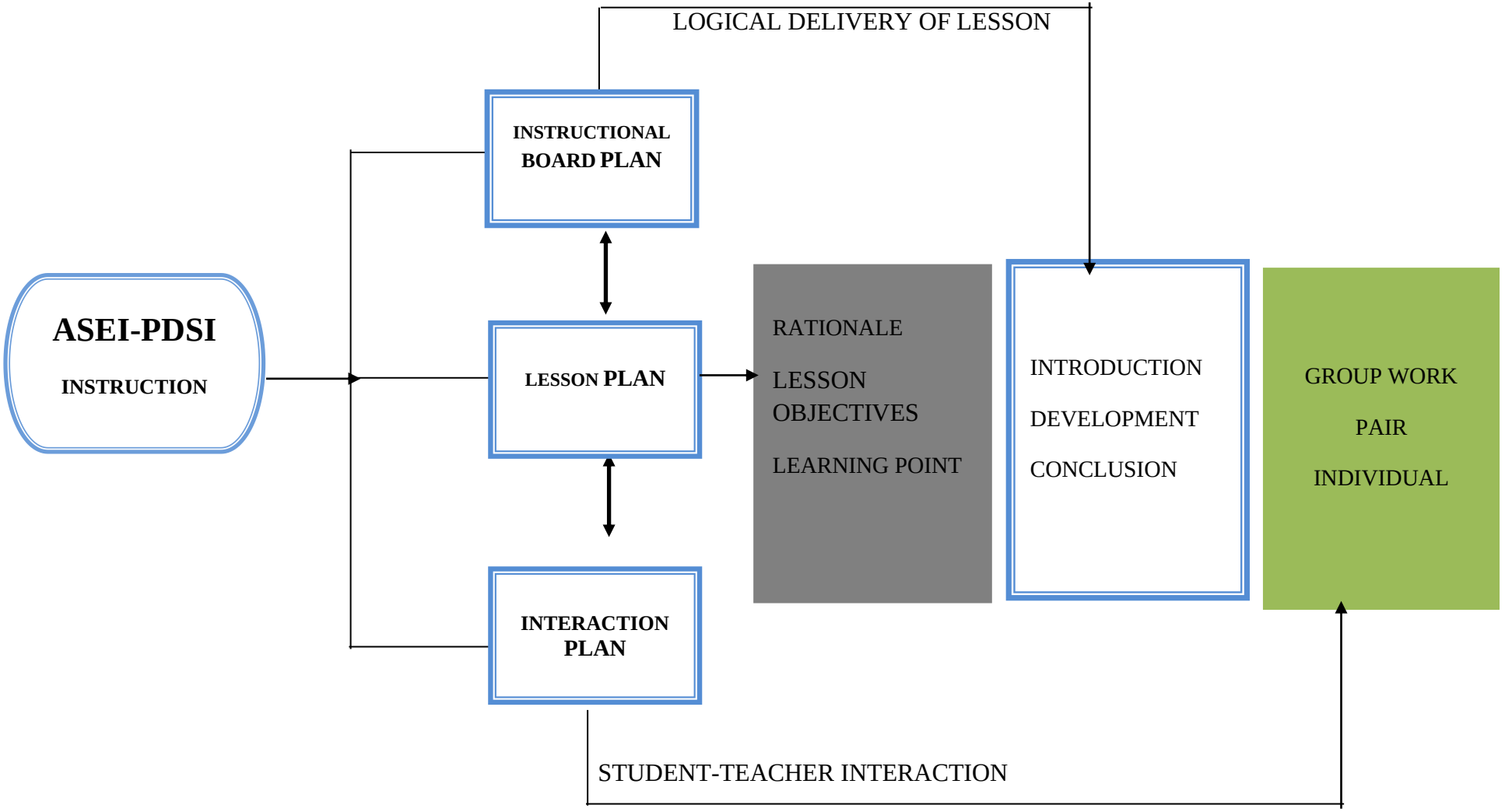


Figure 2*: The Concept of ASEI-PDSI Instruction*

Although, method of instruction is just one of the numerous factors that determine academic success. Academic success may be directly or indirectly linked to many other factors which among others include attitude, self-efficacy, motivation, and anxiety (Wan & Mat, 2013). Attitudes, like achievement, are crucial outcomes of science education, as such every teacher is charged with the responsibility of promoting students' positive attitude towards learning of science (Cheung, 2009).

Understanding students' attitude is essential in supporting students' achievement in particular subject (Wan & Mat, 2013). Although, a substantial body of research has been done on relationships between attitude and achievement in science (Mogane, 2010; Narmadha & Chamundeswari, 2013; Olasehinde & Olatoye, 2014). However, firm conclusions on the existence of cause and effect relationship between attitudes and scores of students have not been established.

Also, there have been evidences that individual's belief about their capacities influence their academic achievement (Fernando, Lawra & Amparo, 2017). The thought that people hold about themselves are double edged sword, they either enhance or hinder their progress (Koura & Al-Hebaishi, 2014). While literature is rich in studies assessing students' self-efficacy, little effort, if not any has been done in answering the question "what can be done to promote self-efficacy among students? This is critical because self-efficacy is seen as a multi-dimensional construct that is elemental to the social-cognitive approach and develops individual's thought as being independent, purposeful, proactive, self-evaluative, and self-regulatory (Bandura, 1989).

There are assumptions that four factors are responsible for self-efficacy, which are: verbal persuasion; secondary experience; enactive mastery experience; and physiological and emotional states (Bandura, 1997). These factors contribute to self-esteem. Thus, self-efficacy

may predict intellectual achievement better than skills alone (Tenaw, 2013). Also, past achievement raises self-efficacy, and students' interpretation of past successes and failures may be responsible for subsequent success (Ferrell & Barbera, 2015). that is, self-efficacy predicts future achievement better than past performance

In addition to ones' beliefs in capacity to excel, researches in science education showed that gender may also influence students' academic achievement in science. The studies of Adebayo (2008), Anwer and Iqbal (2012) showed significant gender difference in students' achievement in science. Gender difference in science is still inconclusive. This is evidenced in the studies of Cheung (2009), Udousoro (2011), Oludipe (2012) which show no significant gender difference in students' achievement in science. This trend is laudable, especially with increasing emphasis on how to boost man power for technological development as well as increasing the participation of females in the field of science and technology.

Aside students' gender, another influential characteristics of an educational system is the way it deals with differences in capacities among students (Jeroen & Ides, 2014). There have been several research studies conducted on how students are arranged within their classrooms. In every classroom, students are placed in groups, either based on their ability levels or randomly assigned by their teachers. The common practice in Nigerian classrooms is that students are either divided by alphabetical pairing; student's choice; or assigned to groups randomly irrespective of which ability level they belong. Thus, the practice of dividing students on basis of their perceived capacities for instruction is ability grouping or tracking (Adodo & Agbayewa, 2011).

The rate of assimilation of science facts and principles differs from one student to another. Hence, the need to divide students based on the level at which they grasp science

concepts becomes imperative. Science educators, as well as educational researchers have struggled to find out who benefit most when students are grouped based on their score levels (Akanmu & Fajemidagba, 2013; Jegede & Olu-Ajayi, 2017). When students are placed in proper groups, students' ability to solve problem and think independently improves (Catalano, 2010), if alternatively, they are placed in a wrong group that doesn't fit their needs, their progress in learning might suffer.

Statement of the Problem

There is no doubt that the knowledge of chemistry is germane to national and technological advancement. However, its teaching/learning is confronted with myriad of challenges such as students' under-achievement, low self-efficacy and negative attitude. Factors, such as inappropriate teaching methods, poor classroom organization by teachers, lack of motivation and so on may be responsible for these challenges. Students' under-achievement is evidenced in the senior school chemistry certificate examinations where less than two-third of the total enrolments in 2007-2019 (Table 1) made it to credit pass. This perhaps, could be the consequences of students' negative attitude and low self-efficacy. This is saddening to a country clamouring for scientific and technological advancement.

Over the years, acid-base chemistry is perceived to be a difficult concept to learnt and one of the areas in chemistry where students achieve less. This claim is substantiated by Kibirige, Osodo, and Tiala (2014); Okam and Zakari (2017), who asserted that senior school students possess misconceptions and difficulties in understanding chemistry concepts such as dissociation and ionization, definition of Browsted-Lowry acids and bases, ionic equilibria, neutralization, pH, buffer solutions and how salts dissolve in water.

Similarly, the WAEC Chief Examiners' report of 2013, 2015, 2017, and 2018 noted that candidates possess poor knowledge of salt hydrolysis, wrote the formula of acid instead

of name, and could not distinguish between acid salts and normal salts. The report also identified students' prevalent weaknesses in concepts such as stoichiometry, oxidation/reduction reactions, balancing chemical equations and solubility, in which acid-base chemistry are pre-requisite to the understanding of these concepts. Hence, the need to advocate for effective teaching and learning of acid-base chemistry becomes imperative.

In view of these, a great deal of efforts have been made over the years by chemistry educators to remediate these problems (Olorundare, 2005). Several innovative strategies were introduced and used, so as to make learning of chemistry more experiential and improve students' achievement. However, most students continue to perform below average. Thus, effective learning of chemistry could include using a more learner-centered strategy such as ASEI-PDSI instructional strategy.

The ASEI-PDSI instructional strategy have been identified as an effective instructional strategy for teaching and learning of science and mathematics in countries like South Africa, Kenya, Zimbabwe, Ghana and so on (Kaman, Wilson, & Thinguri, 2014; Mwangi & Mumgabi, 2013; Mwelese & Awoto, 2014). Their findings revealed a significant improvement in students' achievement and other affective domain of learning such as attitude and interest, when taught using the ASEI-PDSI instructional strategy. Also, the SMASE Nigeria project posited that ASEI-PDSI instructional strategy is effective for enhancing achievement and promoting positive attitude towards learning of science.

In Nigeria, the ASEI-PDSI instructional strategy has been confirmed to be an effective strategy to teach science in the Basic Schools (Adamu, 2017; SMASE, 2010). However, the extent of use of ASEI-PDSI instructional strategy has not been fully confirmed in Nigerian Senior Schools and in the area of chemistry. Thus, in order to bridge the gap and present effort to rectify staggering decline in students' achievement, this study investigated

the effects of ASEI-PDSI instructional strategy on senior school students' achievement, self-efficacy and attitude towards chemistry in Ilorin.

Purpose of the Study

This study examined the effects of the use of ASEI-PDSI instructional strategy on students' achievement, self-efficacy and attitude towards chemistry in Ilorin, Nigeria. Specifically, the study found out:

i. the difference in the achievement of students exposed to ASEI-PDSI instructional strategy and those not exposed to ASEI-PDSI instructional strategy;
ii. the difference in the self-efficacy of students exposed to ASEI-PDSI instructional strategy and those not exposed to ASEI-PDSI instructional strategy;
iii. the difference in the attitude of students exposed to ASEI-PDSI instructional strategy and those not exposed to ASEI-PDSI instructional strategy;
iv. the difference in achievement of male and female students exposed to ASEI-PDSI instructional strategy;
v. the difference in self-efficacy of male and female students exposed to ASEI-PDSI instructional strategy;
vi. the difference in attitude towards chemistry of male and female students exposed to ASEI-PDSI instructional strategy;
vii. the difference in achievement of low, medium and high scorers exposed to ASEI-PDSI instructional strategy;
viii. the difference in self-efficacy of low, medium and high scorers exposed to ASEI-PDSI instructional strategy;
ix. the difference in attitude towards chemistry of low, medium and high scorers exposed to ASEI-PDSI instructional strategy;

x. the interaction effect of achievement with gender and score levels of students exposed to ASEI-PDSI instructional strategy;

xi. the interaction effect of self-efficacy with gender and score levels of students exposed to ASEI-PDSI instructional strategy; and

xii. the interaction effect of attitude with gender and score levels of students exposed to ASEI-PDSI instructional strategy.

Research Questions

The following research questions were raised to guide this study:

i. What is the difference in the achievement of students exposed to ASEI-PDSI instructional strategy and those not exposed to ASEI-PDSI instructional strategy?

ii. What is the difference in the self-efficacy of students exposed to ASEI-PDSI instructional strategy and those not exposed to ASEI-PDSI instructional strategy?

iii. What is the difference in the attitude towards chemistry of students exposed ASEI-PDSI instructional strategy and those not exposed to ASEI-PDSI instructional strategy?

iv. Is there any difference in achievement of male and female students exposed to ASEI-PDSI instructional strategy?

v. Is there any difference in self-efficacy of male and female students exposed to ASEI-PDSI instructional strategy?

vi. Is there any difference in attitude towards chemistry of male and female students exposed to ASEI-PDSI instructional strategy?

vii. What is the difference in achievement of low, medium and high scorers exposed to ASEI-PDSI instructional strategy?

viii. What is the difference in self-efficacy of low, medium and high scorers exposed to ASEI-PDSI instructional strategy?

ix. What is the difference in attitude towards chemistry of low, medium and high scorer exposed to ASEI-PDSI instructional strategy?

x. What is the interaction effect of achievement with gender and score levels of students exposed to ASEI-PDSI instructional strategy?

xi. What is the interaction effect of self-efficacy with gender and score levels of students exposed to ASEI-PDSI instructional strategy?

xii. What is the interaction effect of attitude with gender and score levels of students exposed to ASEI-PDSI instructional strategy?

Research Hypotheses

The following null hypotheses were formulated and tested at .05 level of significance in this study:

H_{01}: There is no significant difference in the achievement of students exposed to ASEI-PDSI instruction and those not exposed to ASEI-PDSI instructional strategy

H_{02}: There is no significant difference in the self-efficacy of students exposed to ASEI-PDSI and those not exposed to ASEI-PDSI instructional strategy.

H_{03}: There is no significant difference in the attitude of students exposed to ASEI-PDSI and those not exposed to ASEI-PDSI instructional strategy.

H_{04}: There is no significant difference in achievement of male and female students exposed to ASEI-PDSI instructional strategy.

H_{05}: There is no significant difference in self- efficacy of male and female students exposed to ASEI-PDSI instructional strategy.

H_{06}: There is no significant difference in attitude of male and female students exposed to ASEI-PDSI instructional strategy.

H_{07}: There is no significant difference in achievement of low, medium, and high scorers exposed to ASEI-PDSI instructional strategy.

H_{08}: There is no significant difference in self-efficacy of low, medium, and high scorers exposed to ASEI-PDSI instructional strategy.

H_{09}: There is no significant difference in attitude towards chemistry of low, medium, and high scorers exposed to ASEI-PDSI instructional strategy.

H_{010}: There is no significant interaction among achievement, gender and score levels of students exposed to ASEI-PDSI instructional strategy.

H_{011}: There is no significant interaction among self-efficacy, gender and score levels of students exposed to ASEI-PDSI instructional strategy.

H_{012}: There is no significant interaction among attitude, gender and score levels of students exposed to ASEI-PDSI instructional strategy.

Scope of the Study

This study examined the effects of ASEI-PDSI instructional strategy on senior school students' achievement, self-efficacy and attitude towards chemistry in Ilorin, Nigeria. The choice of Ilorin was considered appropriate because no evidence of studies on effects of ASEI-PDSI instructional strategy in the area was documented. The target population for the study was all Senior School I (SSI) students in Ilorin, Nigeria. The choice of SSI was considered because this level is the introductory class to chemistry as a subject, thus, developing positive attitude towards chemistry earlier, is essential. Also, ASEI-PDSI instructional strategy has only been used in Nigeria Basic and Upper Basic Schools, introducing the strategy to Nigeria Senior Schools is also necessary.

The contents of the Nigeria Senior School Chemistry Curriculum are categorized into four themes of: The Chemical World; Chemistry and Environment; Chemistry and Industry; and Chemistry and Life. The content of instruction for the study focused on chemistry and environment (acids, bases and salts) because of their importance to industrial development and their interwoven link with everyday phenomena and other concepts in chemistry.

Also, other variables examined in this study were students' achievement, self-efficacy and attitude towards chemistry (dependent) while gender and score levels of the participating students served as moderating variables.

Significance of the Study

The study to a great extent was designed to enhance an instructional strategy that could facilitate the students' understanding of chemistry concepts. The findings of the study might be of importance to students, chemistry teachers, teacher-trainers, federal, state local governments, ministries and other educational bodies as well as future researchers in the field of science education.

The findings from this study will enhance students' understanding of chemistry concepts since they would be in charge of their own learning. The study would be of benefit to both the participants and non-participants in the study. The manipulative skills in students would be enhanced as well as the ability of the students to work with little or no supervision as a result of interactions among themselves. Also, their achievement in examinations will be improved as ASEI-PDSI involves meaningful learning by doing rather than learning by rote.

Specifically, it is envisaged that the findings from this study may help chemistry teachers to improve on instruction development and help them develop more appropriate teaching strategies that will encourage active engagement of students in learning and self-motivation. It would be useful in teacher education programme in formulating teaching and

learning of chemistry standards for the preparation of science teachers in both comprehensive and mastering of appropriate learning strategies that could be used after training.

Teacher-trainers might also benefit from this study using positive teaching in the course of training chemistry teachers emphasizing the inherent nature of chemistry as a subject. Findings from this study therefore would help them to improve on their teaching strategies and consequently, to review their micro teaching and teaching practice assessment format so as to make student- teachers exhibit positive classroom behaviour.

The findings of this study may also be useful to the federal, state ministries and other educational bodies such as Nigeria Education Research and Development Council (NERDC) who need to regularly organize training for teachers so as to update their knowledge to teaching strategies by improving teaching and learning. This study will also serve as reference for educational researchers in their quest to diagnose students' problem in other aspects of chemistry.

Clarification of Major Terms and Variables

The following terms are operationally defined as used in this study:

ASEI: This is an acronym for Activity-based, Student-centered, Experiment and Improvisation. It is an instructional strategy that ensures classroom teaching/learning is student-centered and activity-based through the PDSI

PDSI: This is an acronym for Plan, Do, See and Improve. This is the means through which ASEI is achieved. This involves lesson planning, actual implementation of the planned lesson, lesson evaluation by students and colleagues and improvement in subsequent lessons.

Achievement: Scores obtained by validated researcher designed test items.

Attitude: students' feeling or opinion about learning chemistry.

Self-efficacy: students' beliefs in their ability to succeed in acids, bases and salts

Gender: The state of being a male or female.

Score Levels: This refers to the grouping of students into high, medium and low based on their pretest.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

This chapter focuses on review of related works to this study and were discussed under the following sub-headings:

- ❖ theoretical framework for the study;
- ❖ objectives and contents of Nigeria senior school chemistry curriculum;
- ❖ the concepts of ASEI-PDSI instructional strategy;
- ❖ empirical studies on ASEI-PDSI instructional strategy and achievement in chemistry;
- ❖ studies on students' attitude and achievement in chemistry;
- ❖ influence of gender on students' achievement in chemistry;
- ❖ score levels and students' achievement in chemistry; and
- ❖ appraisal of the reviewed literature

Theoretical Framework for the Study

Studies on human learning is continuous keep developing and expanding. However, educators have divergent opinions on the causes, processes and consequences of learning (Schunk, 2012). Different theoretical traditions apply their ideas and hypotheses in basic and applied situations which give rise to improvements in teaching and learning. Hence, studies on human learning rely on different learning theories

In this study, the framework is hinged on information processing theory and constructivism. The information processing theory is an approach to cognitive development of human being, which deals with the study and analysis of the sequence of events that occur in a person's mind (Beitzel, 2012). The theory is based on the idea that human process the

information they receive, rather than mere responding to stimuli. Hence, the mind is being equated to a computer.

The information processing theory was developed and founded Miller (1956). The theory posited that the spans of absolute judgement and immediate memory impose severe limitations on the amount of information we are able to receive, process and remember. Therefore, the need to organize the information successively into a sequence is imperative. If not, chunks may break or stretch the information bottleneck.

Other contributors to this theory were: Atkinson and Shriffin (1968) stage theory model, which proposed that information is processed and stored in three stages; Craik and Lockhart (1972) levels-of-processing theory, that posited that, learners utilize different levels of elaboration as they process information; Bransford (1979) information accessing model, that suggested that, accessing information closely match the methods used to learn the information; and the connectionistic model of Rumelhart and McClelland (1986) which affirmed that information is saved in multiple locations throughout the brain in forms of network of connections.

According to information processing model standard for the mental development, the mind's machineries include attention mechanisms for bringing information in; working memory for actively manipulating information received; and long-term memory for passively holding information for future use (Huitt, 2003). In learning environment, learners are continually learning and utilizing memory processes in order to store information provided by their instructors. Hence, information processing may be applied in a number of ways which among others include; focusing, information gathering, remembering and organizing (Pappas, 2014).

Similarly, under the umbrella of the constructivism, are many other learning theories such as Piaget's developmental learning theory, Vygotsky's social development theory, Deutsch's classical theory of cooperation and competitive classroom pattern and Bruner's discovery learning theory (Black & Allen, 2018). To a constructivist, the learner learns from having knowledge engrained in a situation and with every new activity, he absorbs more knowledge (Ertmer, & Newby 1993).

The premise of constructivists is that students are shown how to construct knowledge, collaborate with others and come up with multiple perspectives on a problem. The learning takes place in team-based collaborative environments. The instructor becomes a catalyst, a coach, and a program manager (Leonard, 2002). There is need for learners to make their classroom experiences more meaningful and realistic. Berk (2010) affirmed that, Piaget described this need as a drive for equilibrium in which new experiences only make sense when one can explain them using existing understanding. We remain at equilibrium when we understand the new experiences and equilibrium becomes distorted when we can't, which can be re-established if one is motivated (Eggen, & Kauchak, 2013).

In relation to Piaget's submission that a child acts on his environment for learning, and that egeocentricism in a child can be avoided through social interaction with other children, Lev Vygostky also focused on the role of culture and social interactions among children (Daniels, 2001) and describes cognitive development as the connection between social interaction, language and culture.

The major theme of Vygostky's theoretical framework is that social interaction plays a fundamental role in the development of cognition (Culatta, 2018). Vygostky (1978) asserted that every action in the child's cultural development appears firstly between people (interpsychological), and then, inside the child (intrapsychological). That is, the range of

skills that can be exhibited alone by the child is fewer than what is developed with adult guidance or peer collaboration.

Vygotsky's theory is guided by six assumptions: children develop through formal and informal conversation with adults; the first few years of life are essential for development; multiple intellectual activities begin as basic social enterprise; children can perform more difficult task with the help of adults; tasks that are challenging improve cognitive development; and play is important as it stretches the children cognitively (Daniels, 2016).

In the Constructivists classroom, the focus tends to shift from the teacher to the students. The classroom is no longer a place where experts pour knowledge into passive students who wait like empty vessels to be filled. Both the teacher and the learners think of knowledge as a dynamic, realistic and continuous. Thus, view knowledge as not something as inert factoids to be memorized (Black &Allen, 2018). Learners are thereby, stimulated to discover themselves through spontaneous interaction with the environment, rather than feeding them with already made knowledge (Forgaty, 1999).

Constructivist teachers do not take the role of the "sage on the stage." Rather, the teacher act as a "guide on the side". The teacher provides assistance with assimilation of new knowledge; he presents learning as a process of active discovery; makes learning program flexible to permit development along lines of student enquiry; creates situation where students feel safe questioning and reflecting on their own processes; supports collaboration in constructing knowledge and not competition; presents authentic tasks to contextualize learning through real-world, case-based learning environment and facilitate discovery by providing necessary resources as shown in figure 3c.

Figure 3 shows different actions taken by teachers during instruction. Figure 3a illustrates a case of teacher forcing his instruction on students. In such situations, some

students without knowing the teacher's intentions, develop a negative attitude towards the subject. Also, in Figure 3b, the teacher makes reasonable attempt to help the students get the knowledge. However, the teacher only shows the way to knowledge and that doesn't guarantee the knowledge. In Figure 3c, the teacher realizes that he has to walk the journey with students, helping them along the way, get the bright ones going while at the same time moving with the low achievers towards acquiring the same knowledge. Hence, the teacher's approach in Figure 3c left all students feeling happy about learning

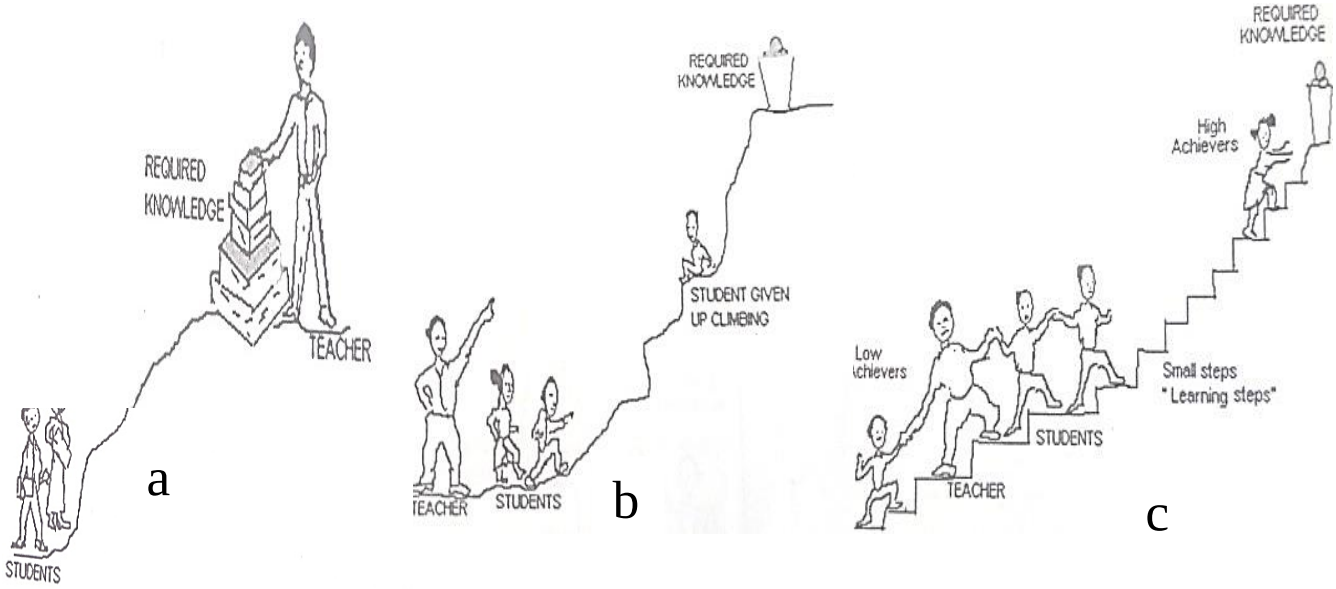


Figure 3*: Different Actions taken by Teachers during Instruction. Source: Adapted from Mwelese & Awoto (2014)*

In view of these, this study is premised by Miller's (1956) submission on the need to organize information acquired into several dimensions and successively into sequence in order to break information bottleneck; and Vygotsky's (1962, 1978) submission on the importance of social interaction in learning. Hence, in this study, the students constructed knowledge by engaging them with active, meaningful, and relevant activities related to their real world experiences in a collaborative manner and process the knowledge successively into sequence.

Objectives and Content of the Nigeria Senior School Chemistry Curriculum

The educational system of every country must have set goals, relevant to the citizen's needs and national development. Here, in Nigeria, the educational goals are defined based on the levels of the education. There are three levels of education in Nigeria: basic, post-basic; and tertiary as represented in the 1-9-3-4 Nigerian system of education respectively, each with stated achievable objectives. These objectives may be far from being achieved, if not properly implemented (Igwe, 2015). Hence, implementation is crucial because the success of most programmes are evidenced at this stage. The extent of this implementation rests solely on the classroom teachers' ability to interpret the curriculum. Thus, the teachers make or mar the curriculum implementation (Ereh, 2005).

Curriculum is defined as the total learning experiences of the individual (SW-Su, 2012). Curriculum is also viewed as what happens to a child in the school as a result of what his teachers do (Olorundare, 2008). From these definitions, it is clear that curriculum is a dynamic process which involves stepwise development that connotes changes. A change in terms of alteration, modification, or improvement of existing condition, that can only be realized if changes are positive, purposeful, planned and progressive (SW-Su, 2012).

Education in Nigeria is an instrument "per excellence" for national and technological advancement. It is for this reason among others that the philosophy and objectives that underline the nation's investment in education is spelt out in clear and unequivocal term in the National Policy on Education (NPE). The Federal Government of Nigeria, FRN (2013), in her policy statement, itemized the specific goals of education in Nigeria, which are to ensure: unfettered access and equity to education for the total development of the individual; the quality of education delivery at all levels; functional education for skill acquisition, job creation and poverty reduction; periodic review, effectiveness and relevance of the

curriculum at all levels to meet the needs of society and the world of work; collaboration with development partners, the private sectors, non-governmental organizations and local communities to support and fund education; and promotion of information and communication technology capability at all levels.

The FRN (2013) posited that Post-Basic Education and Career Development (PBECD) is the education children receive after a successful completion of ten years basic education and passing the Basic Education Certificate Examination (BECE). This includes higher school continuing education in the Vocational Enterprise Institutions (VEIs), and Senior Secondary Education. The curriculum for Senior Secondary Education is consisted of science and mathematics; technology; humanities; and business studies.

Science is seen as multidisciplinary activity which involves planned and systematic investigation for understanding of the universe (Olorundare, 2014). Hence, science comprises of different subjects such as Biology, Chemistry, Agriculture, Physics, Computer, Engineering and others. Chemistry is a branch of science that studies the composition, structure, properties, and change of matter (Ababio, 2013). Chemistry is sometimes called the central science because it bridges other natural sciences, including physics, geology and biology (Adebayo, 2008; Brown, 1999)

Chemistry is in the “tense middle,” occupying a space between several pairs of extremes, perhaps, most importantly, chemistry has always inhabited a frontier between science and technology, the pure and the applied, the theoretical and the practical (Bensuade & Simon, 2008). Hence, chemistry is a combination of science and technology because it often involves the development of a new technique and scientific instrument.

The geographical centre of chemistry, is the laboratory. A place where scientific knowledge and technique meet. Irrespective of the experiment, synthesis, and analysis;

technique is important. Thus, the need to make chemistry more practical oriented is imperative. This is also supported by the position of FRN (2013) in her policy statement that, in order to fully realize the goals of education in Nigeria, educational activities shall be learner-centered for maximum self-development and self-fulfillment and that, teaching shall be practical, activity-based, and experiential.

The Senior School chemistry curriculum is designed in line with the 1-9-3-4 Nigeria system of education following Nigeria's endorsement of international protocols for Education for All (EFA) and the Sustainable Development Goals (SDGs) and adoption of a National Economic Empowerment and Development Strategies (NEEDS), which makes it imperative to update the chemistry curriculum to cater for contemporary needs of the nation.

The objectives of the reviewed chemistry curriculum are to: facilitate a smooth transition in the use of scientific concepts and techniques acquired in the new Basic Science and Technology curriculum with chemistry; provide students with the basic knowledge in chemical concepts and principles through efficient selection of contents and sequencing; show chemistry and its inter-relationship with other subjects; show chemistry and its links with industry, everyday life activities and hazards; and provide a course which is complete for students not proceeding to higher education while at the same time provides a reasonably adequate foundation for a post-secondary school chemistry course (Nigerian, Educational Research and Development Council [NERDC], 2009).

The curriculum content is organized around four themes of: The Chemical World; Chemistry and Environment; Chemistry and Industry; and Chemistry and Life (NERDC, 2009). The content of acids, bases and salts is imbibed under the theme, chemistry and environment for the senior secondary school I (SSI) students. The curriculum is packaged with content that leads to self-actualization by students. Also, curriculum content focuses on

practical activities with emphasis on locally available materials. This is to imbue the learners with the spirit of enquiry. The themes of the curriculum are organized into instructional units which are sequenced in spiral course progresses, from SSI through SSIII and are organized in seven columns of topic; performance objectives; content; teacher's activities; students' activities; teaching and learning materials; and evaluation guide.

However, it is worthy to note that, the studies of Uchegbu, *et al.* (2016); Ugwu (2014) revealed that Nigeria Senior School students perceived 13 chemistry topics (65%) in the curriculum difficult to comprehend. Hence, recommended that the SSCE chemistry curriculum should be reviewed by examination bodies; and chemistry teachers should adopt guided discovery approach which rest squarely on the activity of students and deals with students' misconception in chemistry and help them identify their misconception

On this note, the objectives the chemistry curriculum has posed a great challenge to secondary schools with a lot of implication for the instructional methods used by chemistry teachers. This is because the degree of nation's success or failure in her drive towards scientific and technological advancement is hinged on the efforts made by science teachers towards meeting the set objectives.

Concept of ASEI-PDSI Instructional Strategy

The Japan International Cooperation Agency (2006) affirmed that the aim of SMASE (Strengthening Mathematics and Science Education) projects in Africa is to shift teaching paradigm from chalk and talk to ASEI-PDSI instructional strategy. This project is ongoing in several African countries such as Kenya, Ghana, Malawi and so on, and the ASEI-PDSI instructional strategy has been confirmed to be effective. This strategy ensures quality of science and mathematics lessons where students take charge of their own learning in a meaningful way.

The assumption of the SMASE Nigeria is that learners become actively involved whenever a lesson attains ASEI status. It elicits great interest and responsiveness among learners, thereby, increasing their level of understanding and retention of knowledge. Also, its premise, is that every concept to be learnt must be activity oriented, as this makes learning more permanent and also encourages active involvement of learners during the teaching/learning process. In order to achieve these, PDSI is employed.

The PDSI is a means through which ASEI can be achieved. The teacher plans, presents, sees and improves on subsequent lessons, based on the observation made by students, colleagues or supervisors (SMASE, 2010). A teacher has to apply his content and pedagogical knowledge in planning and delivering his lesson respectively. Thus, a teacher has to prepare a framework of his subject or topic in written form known as lesson planning (Hibah, 2010). Lesson plan therefore is the title given to the statement of the achievement to be realized and the procedures by which these are to be attained.

If the assumption that teaching is organized into three phases of; pre-active, interactive and post-active phase holds. Then, all the activities of a teacher such as collecting resources for teaching, preparing the blueprint (plan), done prior of the timings of his class are called the pre-active phase of teaching (Hibah, 2010). As such, the importance of lesson planning cannot be over-emphasized in classroom instructions as it gives the teacher greater assurance and greater freedom in teaching, provides adequate lesson summaries and most importantly, saves teacher from haphazard teaching (Mallick, 2012). Hence, adopting ASEI-PDSI instructional strategy requires the teacher to develop a lesson plan, interaction plan and chalkboard plan for every lesson (SMASE, 2018).

Generally, lesson plan is divided into two sections, namely: the general information section; and the presentation section (SMASE, 2010). The general section is characterized by

basic information about the subject matter and students' background which among others include subject, topic, sub-topic, class, average age of the learners, duration, instructional materials, reference materials, previous/pre-requisite knowledge, learning objectives, rationale and so on (SMASE, 2010). The presentation section is presented in a tabular form of four columns of: steps; teacher's support; learners' activity; and learning points respectively (SMASE, 2010). This isn't different from the conventional lesson plan format apart from rationale and learning points introduced at the general information and presentation section respectively.

The premise of SMASE Nigeria project is that all topics to be taught to a particular set of learners must be justified. That is, if a teacher provides justification for teaching a concept to a set of learners and relates this concept to the learners' immediate environment, then, the problem of inability to state the lesson objectives is rectified (SMASE, 2010). On the other hand, ASEI-PDSI instructional strategy is activity-oriented, it is imperative for teachers to provide the learning point at each step of the development of lesson delivery so as to show the objective the teacher seeks to achieve at that step. For instance, at introduction step, if a teacher poses a question in order to link the previous knowledge to the new concept. Then, it has to be stated as the learning point.

SMASE Nigeria also assumes that learners' entry behavior can be categorized as either previous knowledge or pre-requisite knowledge. Its assumption is that they are not synonymous, although, they are being used interchangeably. Previous knowledge refers to the information or knowledge the learners possess outside the formal classroom setting that is related to the new concept. And that, pre-requisite knowledge is that knowledge the learners possess in the formal classroom that is rudiment to the new concept under discussion (SMASE, 2010).

On the other hand, interaction plan is a plan that shows the strategies a teacher seeks to employ in order to control the quality of learning outcomes (SMASE, 2018). Thus, interaction plan is used to maintain conversation, teach, or interact with students in teaching and learning in the classroom (Rhalmi, 2016). Also, interaction is the heart of social constructivists who contend that human development is socially situated and knowledge is constructed through interaction with others (Rhalmi, 2016). Hence. for effective learning, there is need for interaction between teacher, learners and learning materials. Classroom communication involves different interaction patterns, which among others are: student to student (pair work); student to the class; group work; student to teacher; teacher to students; and teacher to individual student. It is imperative for teacher to vary interaction patterns as more variety means that the students are always engaged.

Also, for better actualization of ASEI lesson, it is crucial to plan for what is to be written on the instructional board. This enables the teacher to clarify the points of the lesson and to reinforce the logical flow of the lesson. Instructional board plan also allows the students to see the sequence of activities to reach the lesson objective(s) and serves as road map to reach the conclusion. Thus, the instructional board should be divided into three parts, each part corresponding to a step of the lesson plan and should be written from the top to the left bottom, then to the right (SMASE, 2018).

Hence, to the ASEI-PDSI advocates, teachers serve as models to their learners and through extensive and conscious planning on the part of the teacher, followed by elaborate implementation of the plan in a well prepared environment where problem-solving abilities are transferred to the learners (McLeod, 2011). Teachers' level of preparation, delivery and motivation of learners in ASEI-PDSI classroom enhanced students' achievement, self-efficacy and positive attitudinal change towards chemistry as shown in Figure 4

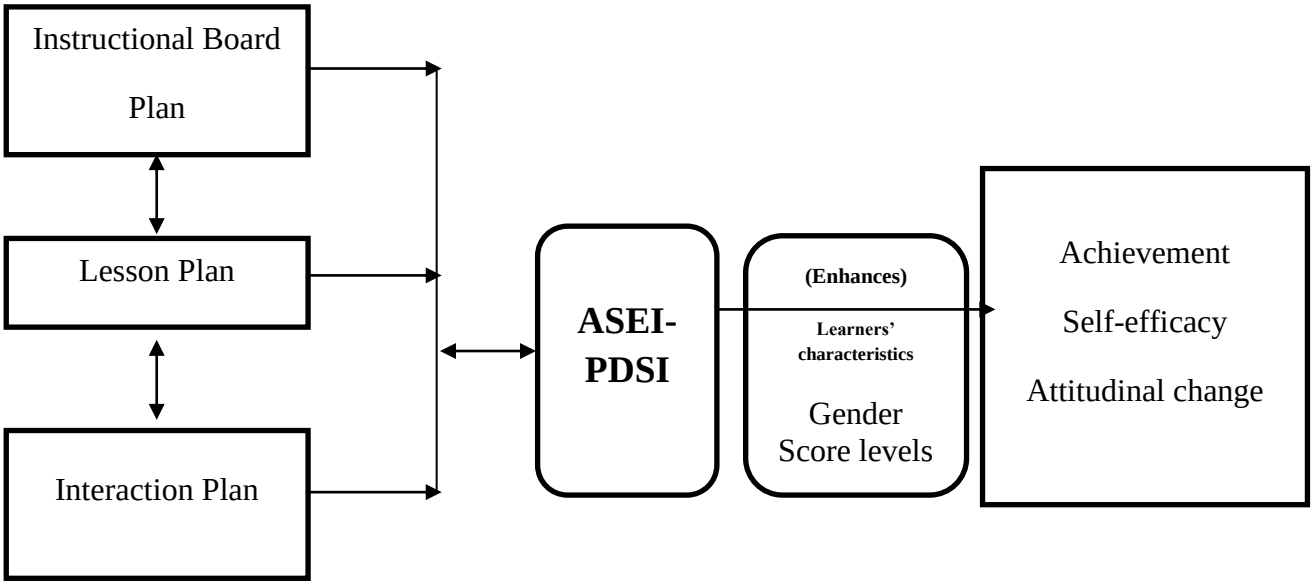


Figure 4*: Researcher's Model for the Study*

Empirical Studies on ASEI-PDSI Instructional strategy and Students' Achievement

Several instructional strategies are used in science classes that vary from those that are excessively instructive to those that are student-centered. However, most times, teachers adopt the traditional deductive method of teaching. This implies that, the major problems faced by science teachers is not necessarily "what to teach" but how to teach science effectively. The way teachers teach science matters a lot, as effective learning depends on the method(s) adopted by the teacher. There are various methods of teaching science; however, a better method is any method the teacher uses to promote learning (SMASE, 2010).

Teaching and learning are very complex processes that are influenced by many factors, only some of which are under the teacher's control and none of these is fully understood (Killen, 2008). Hence, no single strategy is effective all the time for all learners. Many studies have been carried out on effects of several instructional strategies in order to remediate poor achievement of students in chemistry such as concept mapping, students'

team-achievement division, advance organizer, motivational, activity-based, inquiry, and discovery and so on.

Innovation is the creation of better or more effective products, process, services, technologies or ideas that are accepted by markets, governments, and society (Ndirangu, 2017). The SMASE In-Service Education and Training (INSET) provides a forum for mathematics, biology, chemistry, and physics teachers in secondary schools to gain new ideas, revise their knowledge on content matter, pedagogical issues, curriculum development and any other aspect that would improve their professional competence (Kiige & Atina, 2016). Perhaps, the education system in Japan has succeeded because it embraces continuous in-service programs for its teachers through mentorship research groups and workshops (Odhiambo, 2016).

The principle of ASEI-PDSI instructional strategy serve as a foundation upon which teachers can build a substantive and sustainable change in classroom practices with ultimate aim of enhancing the quality of teaching and learning of science and mathematics (SMASE, 2010). Hence, ASEI-PDSI instructional strategy considers quality of classroom activities as critical to achieving effective teaching and learning and thus, enhances achievement in science and mathematics.

Protus, Martin, and Shikuku (2020) investigated the impact of SMASSE's ASEI-PDSI techniques on attitude of secondary school students towards mathematics in baringo county, Kenya. The objective of the study was to find out whether the use of ASEI-PDSI technique would influence students' attitude towards mathematics. The study was a descriptive research type and a sample size of 11 heads of department, 42 mathematics teachers, and 272 students were involved in the study. The data gathering tool were questionnaires and interview protocol and the resulting data were anlysed using frequency,

the percentage and *t*-test inferential statistics. The findings of the study showed a significant difference in the attitude of students taught by teachers who attended SMASSE trainings and those students taught by teachers who do not attend the training, which was in favour of the students taught by teachers who attended SMASSE training. Hence, the study concluded that ASEI and PDSI techniques improve attitude towards mathematics.

Ambasa, Ayere and Rabari (2019) investigated teachers' and students' use of ASEI-PDSI approach in teaching and learning of primary science in Inemuhaya sub-county, Kenya. The objective of the study was to determine extent of utilization of ASEI-PDSI strategy in teaching primary science. The study was a descriptive one, and 662 respondents were sampled. Questionnaires for science teachers, head teachers and class eight pupils were used to collect data. The data collected were analyzed using descriptive statistics of mean and the percentage. The finding was that the ASEI-PDSI approach was not frequently used by teachers.

Adamu (2017) examined primary six pupils' performance in mathematics using ASEI instructional strategy in zaria local government of Kaduna state. The study was a pretest posttest quasi experimental research design with sample size of 200 primary six pupils randomly selected from four co-educational schools. Mathematic performance test one and two (MPT_1 and MPT_2) were used to gather data. The data gathered were analyzed with mean and *t*-test. The findings revealed that ASEI instructional strategy had significant impact on pupils' performance in mathematics; there was no significant difference in performance of male and female pupils exposed to ASEI strategy; and there was no significant difference in performance of students in rural and urban areas. Hence, the study concluded that ASEI instruction is effective and gender sensitive.

Ndirangu (2017) found out there was significant relationship between the teachers', head teachers' attitude, and the level of implementation of ASEI-PDSI instructional strategy in his study on attitude of teachers towards implementation of ASEI-PDSI in science education in Kenya. The objective of the study was to evaluate the attitude of teachers towards implementation of ASEI-PDSI instruction in Kenya. The study was a survey type and adopted purposive, stratified and simple random sampling technique in selecting 68 head teachers, 147 biology, chemistry and physics teachers and 16 trainers. The data gathered were analyzed using chi-square statistics.

Kiige and Atina (2016) investigated the extent to which mathematics and chemistry teachers have employed the use of ASEI and PDSI approaches of SMASE in schools in Kenya. The study utilized a cross-sectional approach of on point in time descriptive design. A total of 16 schools were selected using stratified random sampling technique. The data collection was done by the use of questionnaires, review of available documents, and focus group discussion. The data gathered were analyzed using the percentage, trend lines, frequency distribution and means. The findings indicated that ASEI-PDSI are in use and have improved the teachers' confidence and ability to deliver.

Odhiambo (2016) evaluated ASEI-PDSI instruction and performance in mathematics in public primary schools in Kisumu west sub county, Kenya. The study examined the correlation between level of implementation of ASEI-PDSI instruction and teachers' attitude; and relationship between head teachers' supervision of ASEI-PDSI and performance in mathematics. The study was a descriptive design and involved 29 head teachers, 60 science teachers and 310 pupils in the study. The data gathering tools were questionnaires for head teachers and teachers and ASEI-PDSI checklist. The findings showed that teachers had

negative attitude on the use of ASEI-PDSI principles as opposed to their pupils whose responses reflected a lot of interest and positive energy around many aspects of ASEI-PDSI.

In the study of Barasa (2015), attempt was made to find out the influence of strengthening mathematics and science education on pupils' performance in science in public primary schools in samia sub-county, Kenya. The purpose of the study was to examine the influence of teachers' use of improvised learning resources, teachers' attitude, teachers' lesson planning, and use of learner-centered approaches on students' performance in science. The sample comprised of 18 head teachers, 18 standard eight teachers and 190 standard eight pupils. The data were gathered using interview guide and questionnaires. The findings of the study showed that 77.8 percent of teachers experienced difficulty in planning ASEI-PDSI lessons and, that ASEI-PDSI has not been fully implemented as expected by SMASSE.

In Ayeigo, *et al.'s* (2015) study on the extent of practice and implementation of ASEI-PDSI approach by teachers of mathematics in Vihiga county, Kenya, the findings revealed that the practice of PDSI rated 4.332 on a 5-point likert scale and that 95.89% of the teachers employed ASEI approach. The purpose of the study was to establish the role preparedness of stakeholders and the extent of practice and implementation of ASEI-PDSI approach by teachers of mathematics. The study adopted a descriptive survey research where 38 school principals, 38 HODs of mathematics, 136 teachers of mathematics and 3 education officers constituted the sample. The data gathering tools were principals' questionnaire, questionnaire for HODs, mathematic teachers' questionnaire, and interview schedule for education officers.

The objectives of the study of Mwelese and Awoto (2014) were to determine the effects of the ASEI-PDSI instruction on students' achievement; views; and attitude towards the learning mathematics. The study adopted a true experimental design based on Solomon-

four fold design and a total of 152 subjects were involved in the study. The data gathering tools were achievement test, questionnaires, interview schedules, and video recording. The findings showed that ASEI-PDSI had a significant effect on students' achievement. Also, students taught with ASEI-PDSI had a better view and attitude towards mathematics than those taught without ASEI-PDSI.

Studies on Students' Attitude and Achievement in Chemistry

Attitude is a conceptual belief that indicate like or dislike towards an item. It may be positive, negative or neutral (Khan & Ali, 2012). Studies in science education on the influence of attitude and correlations between science related attitudes and science achievement are numerous. However, firm conclusions as to the existence of cause and effect relationship between attitude and achievement in science have not been established. Most researches concerned see attitude as outcomes, rather than the role of attitude as determinant of scores.

Wahyudiati, Rohaeti, Wiyarsi, and Sumardi (2020) investigated the influence of gender and grade level on pre-service chemistry teachers' attitude, self-efficacy and learning experience in universities in Mataram. The study was a cross-sectional survey method with a sample size of 191 pre-service chemistry teachers that comprised 130 male and 60 female participants. The chemistry attitude and experience questionnaire was used to collect data. The data gathered were analyzed using MANOVA. The findings were that: the pre-service chemistry teachers had the highest level of learning experience; grade level did not influence the difference between self-efficacy and attitude towards chemistry; and gender did not influence the difference among learning experience, self-efficacy and attitude towards chemistry.

Abulude (2016) investigated the attitude of teachers and students towards chemistry in selected secondary schools in Akure south local government area of Ondo state, Nigeria. The study sought to find out senior school students' attitude towards chemistry and if chemistry should be made compulsory to all science students. The study was a survey type that involved 300 senior school students randomly selected from five public schools in Akure south. The data gathering tool was a researcher designed questionnaire, and the data gathered were analyzed using descriptive statistics of frequency and the percentage.

The findings of the study revealed that: both students and teachers had negative attitude towards chemistry; factors such as inadequate textbooks, poor instructional materials and government-oriented problems were responsible for negative students' attitude towards the subject. Hence, the study recommended that students' attitude may be improved, if they are more involved in classroom activities and that government should make available instructional materials, equipment, and resources, especially in the area of chemistry.

Kenar *et al.* (2015) investigated ninth grade students' attitude towards daily life chemistry. The study examined students' attitude towards chemistry of everyday life of high school ninth students based on gender, learning and educational levels of mother and father, father's profession and income level. The study was a survey type and consisted of 159 ninth grade students of Anatolian high school, selected using convenience sampling technique.

The data gathering tool was Daily Life Chemistry Attitude Scale (DLCAS). The DLCAS comprised of 25 items with responses on five likert scale. The data gathered were analyzed using independent *t*-test, ANOVA and Tukey's HSD test. The study found out that: a significant difference existed between gender and daily life attitude; female students had more positive attitude towards daily life chemistry than their male counterparts; a significant difference existed between students' attitude towards daily life chemistry and the educational

status of their parents; and there was also a significant difference between students' attitude towards daily life chemistry and their parents' income.

Achor (2013) conducted a study on promoting students' attitude using concept mapping strategy in difficult chemistry concept. The study also investigated the difference in attitude of male and female students offering chemistry and adopted quasi experimental research design. The target population was SSII students offering chemistry in Benue state while a sample size of 1357 subjects were involved in the study. The chemistry student attitude questionnaire was used to collect data, the data gathered was analyzed using mean, standard deviation and ANCOVA. The findings were that students in the exposed to concept mapping strategy had higher attitude rating score in chemistry than their control group counterparts. Also, female students exhibit more positive attitude than the male students.

Khan and Ali (2012) investigated the Pakistanis higher secondary school students' attitude towards chemistry. its objectives were to examine higher secondary school students' attitude towards chemistry subject; chemistry teachers and their teaching methodologies using a descriptive research of the survey type. The population for the study was all the higher secondary school students of Khyber pakhtunkwa, Pakistan while the sample was 35 second year students of government higher secondary school of jamrud Khyber agency were selected using convenience sampling technique. The data gathering tool was a validated attitude scale questionnaire. The data gathered were analyzed using mean score of each statement. The findings revealed that students were very much satisfied with their chemistry teacher; students have worries about the subject and methodology of chemistry.

Festus and Ekpete (2012) investigated the efficacy of problem-based-solving techniques (PBST) on performance and attitude of students towards chemistry. The main purpose of the study was to examine if method of instruction could change students' attitude

towards chemistry. The study adopted a correlational and survey research designs and the sample for the study was 98 senior secondary school II students in obior/akpor local government area of Rivers state, Nigeria.

The data gathering instrument was a validated researcher developed test items and the data gathered were analyzed *t*-test statistics. The findings revealed that, the performance of experimental group in problem solving was enhanced than those in the control group; students in the experimental group had better perception and attitude toward the use of PBST in study chemistry. hence, the study established that acceptable methods of instruction are capable of promoting students' performance and attitude towards chemistry.

Tuysuz (2010) investigated the impact of the virtual laboratory on achievement and attitude of students towards chemistry. The study employed quasi experimental research design of pre and post-test control group design involving 341 high school students in turkey. Knowledge Scale (KS) and Chemistry Attitude Scale (CAS) with reliability coefficients of 0.86 and 0.92 were the data gathering tools. The data gathered were analyzed using paired samples *t*-test and independent *t*-test. The findings revealed that there was significant difference in the performance of students taught using virtual laboratory and those taught with conventional method favoring the experimental group ($p < .05$); and that instructional method used may have significant effect on students' attitude towards chemistry, as there was significant difference in attitude of students exposed to treatment and those not exposed to the treatment, favoring the treatment group.

The aim of Mogane's (2010) study was to assess the correlation between attitudes and learning outcomes of first year medical students towards chemistry and the relationship between attitudes of students and their learning outcomes in chemistry. The type of knowledge the students had acquired was correlated with the attitudes they developed along

the teaching and learning process. Hence, the study was a retrospective ex-post facto-correlational research. The study sample comprised of 103 medical students in chemistry I class at higher education institution in Gauteng selected using convenient sampling technique. The sample was made up of 48 female and 55 male students.

The instrument for data gathering was a researcher developed Chemistry Attitudes Questionnaire (CAQ). Descriptive analysis was employed to assess the attitudinal disposition of students towards chemistry and for their learning outcomes; Pearson correlation statistics was employed to obtain the relationship of attitudes of students and their learning outcomes as well as the relationship of their overall score in the examination and their performance in different knowledge components; and Simple linear regression analysis was also employed to obtain which variable predicted the learning outcomes of the students.

The study revealed that: the respondents have negative attitudes towards chemistry; the results of the relationship between attitudes scores of students and their scores in the two knowledge components were significant; and a high correlation was observed among relationship of declarative knowledge with overall performance. Correlative knowledge with procedural knowledge were positive but weak. It was concluded that the need to know our students' attitudes towards science and the effect they have on learning outcomes is imperative, so as to enhance the quality of teaching.

Students' Self-Efficacy and Achievement in Chemistry

Several studies have been conducted on self-efficacy and academic achievement but there has not been any adequate linkage between self-efficacy beliefs and achievement in science. Self-efficacy, otherwise known as perceived ability, refers to the confidence people have in their abilities to excel in a given task (Bandura, 1997). Any individual that possesses a reasonable degree of self-efficacy are likely to attempt challenging task, and exert more

effort while performing the task. Thus, when they succeed, they credit their abilities (Bandura, 1997).

Zarkasyi and Partana (2020) examined the self-efficacy of senior high school students in chemistry in Indonesia. The study adopted a descriptive research of the survey type. A sample size of 77 senior school students were considered using a self-efficacy indicator as the instrument. The results were analyzed using frequency, percentage and bar graph. The findings revealed that more than half of the students had high self-efficacy and that self-efficacy is influenced by motivation, experience, psychology, and social environment.

Fitriana, Niyaris, and Sugiyarto (2018) examined the effects of video conference and android-based game on students' self-efficacy profile in hydrocarbon hybrid. The study was a descriptive research with a sample size of 143 grade 11^{th} students selected randomly from two public senior schools in Purworejo regency, Indonesia. A self-efficacy questionnaire was used to collect data and the resulting data was analyzed using descriptive statistics of mean and the percentage. The finding was students in combined class of video conference and android-based game had the highest self-efficacy profile.

The study of Baanu, Oyelekan, and Olorundare (2016) was an ex-post facto research that examined senior school students' self-efficacy and their academic achievement in chemistry in north-central, Nigeria. The sample is comprised of 1150 SSIII students selected from 10 secondary schools in Kogi, Kwara and Niger States. The data gathering tools were validated self-efficacy questionnaire and chemistry results of the respondents in joint mock school certificate examinations. The resulting data were analzed using mean, percentage and Pearson Product Moment Correlation. The findings revealed no significant relationship between self-efficacy and achievement in chemistry.

Mari and Gumel (2015) investigated the effectiveness of jigsaw cooperative learning on self-efficacy and achievement of colleges of education students in Nigeria. The study was a pretest-posttest experimental control group design. The population is comprised of 200 level chemistry students of 7 state colleges of education in the north-west geopolitical region. 180 participants comprising of 126 formal reasoners and 54 concrete reasoners constituted the sample. The data gathering tools were general self-efficacy subscale, chemistry achievement test and test of logical thinking. The resulting data were analyzed using mean, standard deviation, and *t*-test statistics. The findings of the study revealed that cooperative learning strategy could be an alternative strategy of teaching chemistry in colleges of education because it has the capability of enhancing academic performance of formal and concrete reasoners in chemistry.

Ferrell and Barbera (2015) evaluated students' self-efficacy, interest, and effort beliefs in general chemistry. The objectives of the study were to measure personal interest, effort beliefs and self-efficacy of college students in chemistry using the existing measures of personal interest and effort beliefs in chemistry context and a modified chemistry-specific measure of self-efficacy. The scales were administered twice in general chemistry course to a sample of 667 undergraduate students. The study reported that chemistry major reported higher self-efficacy and interest than non-science majors

Tenaw (2013) conducted correlational study among students' variables of self-efficacy, academic achievement and gender in analytical chemistry at Debre Markos College of Teacher Education. The study investigated the relationship between Analytical Chemistry I (ACI) course self-efficacy and achievement with gender of second year chemistry and biology students in the fall of 2012 in analytical chemistry. The study adopted a survey research. The participants of the study were students of DMCTE who originally came from eleven administrative zones of the Amhara region. 100 students out of 222 enrolled in ACI

were selected using systematic random sampling technique. The subjects included 45 females and 55 males. The instruments for data gathering were self-efficacy scale (SES) and students' achievement test. The data gathered were analyzed by computing mean and standard deviation and reporting percentage for each demographic choice, *t*-test inferential statistics was used to determine statistical significance and difference and also, difference of self-efficacy and achievement in gender was calculated using Pearson Correlation.

The findings of the study showed that: students' self-efficacy level was medium (50.08); gender did not significantly influence students' self-efficacy; gender significantly influence achievement; and a significant relationship existed between self-efficacy and achievement in chemistry. Hence, concluded that, self-efficacy and achievement were positively and significantly related.

Akomolafe, Ogunmakin, and Fasooto (2013) investigated self-efficacy, motivation and self-concept as predictors of senior school students' performance. The study sought to find out if some psychological factors such as self-efficacy, motivation and self-concept would significantly could predict students' performance in Nigeria. The study adopted a correlational type of descriptive design. 398 senior secondary school III students comprising of 204 males and 194 females selected in Ondo State using stratified random sampling technique constituted the. The tools used for data gathering were: Self-in-School Scale (SSS); Students' Academic Achievement Motivation (SAAM); and Academic Self-Concept Scale (ASCS).

The data gathered were analyzed with multiple regression analysis, Pearson correlation and ANOVA. The findings of the study revealed that: significant positive correlations among performance and self-efficacy, motivation, and self-concept; 56% of the total variance in performance of senior secondary school students was accounted for by linear

combination of self-efficacy, motivation, and self-concept. Hence, self-efficacy, motivation, and self-concept when pulled together significantly predicted performance of secondary students. It was concluded that self-efficacy made the most contribution to performance, followed by self-concept and motivation respectively.

Ahmad (2012) conducted a study entitled Relationship among Academic SE, Self-Regulated Learning, SI, Test Anxiety and Academic Achievement. The study examined the extent to which self-efficacy beliefs could predict academic achievement. The sample was 426 grade 10 students comprising 221 girls and 205 boys purposively selected from four single sex schools in Lahore. The instruments for data collection were: children SE scale; SE for self- regulated learning; school questionnaire; and science anxiety scale.

The data gathered were analyzed using the percentage, Pearson, r, independent *t*-test and hierarchical multiple regression. The findings of the study showed that: academic SE significantly correlated with other variables ranging from 0.40 to 0.70, where the strongest correlation was found between SE and SE for SR; test anxiety was found to have significant negative correlation with academic SE, SE for SR, SI and academic achievement; no gender differences were found in academic SE, SI and SI; gender differences in students' SE for SR and academic performance were significant favoring the male students in SE for SR and female students in performance in examination. It was concluded that self-efficacy beliefs at academic domain level were found to contribute significantly to the prediction of academic achievement.

Kurbanoglu and Akim (2010) examined laboratory anxiety, attitude and self-efficacy beliefs of university students in Turkey. The sample for the study was 395 (236 females and 159 males) first year major undergraduates randomly selected from four universities' general chemistry and general chemistry laboratories classes. The instruments for data collection

were chemistry laboratory anxiety scale, chemistry attitude scale, and self-efficacy scale with reliability coefficients of 0.86, 0.83 and 0.86 respectively.

The data gathered were analyzed using mean, standard deviations, inter-correlations. The results showed that chemistry laboratory anxiety did not correlate with chemistry attitudes and self-efficacy, chemistry attitude were found to be positively associated with self-efficacy, and self-efficacy had a direct and positive effect on chemistry attitudes which in turns affects chemistry laboratory anxiety. Thus, the study emphasized that the relationships among self-efficacy, chemistry laboratory anxiety and chemistry attitudes were positive.

Nbina (2010) investigated the effectiveness of instruction in metacognitive self-assessment strategy on chemistry students' self-efficacy and achievement in Port Harcourt education zone. The study was a quasi-experimental research design and the population was all senior secondary school (SSII) students. 192 students comprising of 91 boys and 101 girls were selected using multi-stage sampling technique, constituted the sample for the study. The data gathering tools were chemistry achievement test, self- assessment scale and chemistry self-efficacy scale. The data collected were analyzed using mean and standard deviation, and Analysis of Covariance (ANCOVA). The findings of the study indicated that instruction in metacognitive self-assessment strategy significantly improved the chemistry achievement of senior school students and enhanced their self-efficacy.

Influence of Gender on Students' Achievement in Chemistry

In the field of science education, gender as a factor interacting with learning cannot be omitted. Especially with increasing emphasis on how to boost man power for technological development as well as increasing the population of females in the field of science and technology. Hence, many researchers have focused their attention on studies relating to its effect on students' achievement in science.

Gender, even though does not determine what a person does or becomes in the society, it is viewed as social construct that establishes and differentiates status and roles between men and women, particularly in the way they contribute to, participate in, and rewarded in the society (Tahir, 2004). In recent decades, policy makers, research organizations, and funders of science have made efforts to increase the participation of women in science (Rabesandratana, 2014). This is evidenced in the European Commission engendering research by giving guidelines on how to include gender in EU funded projects. However, while it is important to consider gender in research, gendered innovations highlight the risk of over-doing it (Rabesandratana, 2014).

Studies on gender influence on academic achievement have not produced a conclusive result, where some findings indicated that a significant difference exists between the achievement of male and female students, other findings showed that gender factor had no effect on students' achievement. While some researchers reported that male students performed significantly better than their female counterparts in science and mathematics, others asserted that female are vaster in science and mathematics than their male counterparts.

Ajayi and Ogbeba (2017) examined the effects of hands-on activities on senior school students' achievement in stoichiometry with gender as a moderating variable. The objectives of the study were to determine the difference in male and female students' achievement when taught with hands-on activities and the interaction effect of gender and treatment on achievement of students. The study was a quasi-experimental design and the population was all SSII students in Benue state and a sample of 292 subjects were involved in the study. Stoichiometry achievement test was used to gather data, the data gathered was analyzed with ANCOVA. The findings were that, no significant difference existed in male and female

students' achievement in chemistry and no significant interaction existed between gender and treatment.

The objectives of Bamiro's (2015) study were to find out the influence of cognitive entry behavior and gender on students' achievement in chemistry when taught with guided discovery, think-pair-share, and lecture methods. The study adopted 3x3x2 pretest posttest control group quasi-experimental design. 242 senior school I students in intact classes from six senior schools in Ijebu-ode and odogbolu local government areas of ogun state, Nigeria constituted the sample.

The data gathering tools were validated learning instructional guide, chemistry cognitive entry point test, and chemistry achievement test. The resulting data were analyzed with Analysis of Covariance, multiple classification analysis, and Scheffe's post hoc test. The findings of the study revealed that think-pair-share strategy had the greatest effect on students' achievement in chemistry and the intervening variables jointly accounted for 43% $(0.656)^2$ of the variation in the students' scores in chemistry.

The interaction effects of gender and grade level on attitude towards chemistry was examined by Heng and Karpudewan (2014). The purpose of the study was to measure the interaction effect of gender and grade level on secondary school students' attitude towards learning chemistry from Malaysian prospective. The sample for the study was 446 students comprising of 191 males and 225 females randomly selected from seven schools in the district of Perak and the data gathering tool was questionnaire on the attitudes toward chemistry lesson (ATCLS). The data gathered were analyzed using a two-way multivariate analysis of variance (MANOVA).

The findings of the study showed that: gender and grade level significantly influence attitude towards chemistry; gender and grade level had significant interaction effect on

secondary students' attitude towards chemistry; all the four subscales exhibited significant interaction effects between gender and grade level; grade level was significant to all four dimensions; and generally, female students had more positive attitude towards chemistry than their male counterparts.

Aniodoh and Egbo (2013) ascertained the efficacy of inquiry role instructional model in teaching chemistry and expository method on male and female students' achievement in chemistry. The study adopted a quasi-experimental research design, the sample for the study was 141 SSII students offering chemistry purposively selected from two boys and two girls only schools in Enugun. The data gathering tool was chemistry achievement test (CAT). The CAT comprised of 40 multiple choice questions on qualitative analysis.

The data gathered were analyzed by finding the mean and standard deviation; ANCOVA inferential statistics was used to test for the hypotheses at .05 level of significance. The findings of the study revealed that: the treatment had positive influence on the achievement of students in chemistry; the female students performed better in chemistry than their male counterparts using inquiry role instructional model. However, this difference was not statistically significant. Thus, concluded that inquiry model was found more effective than expository method.

Udousoro (2011) examined the gender influence and mathematics ability on students' achievement in chemistry. The study adopted a survey research the sample for the study consisted of 100 SS1 students comprising of 56 males and 44 females offering chemistry purposively selected in two secondary schools in Uyo. The Chemistry Achievement Test (CAT) and Mathematical Ability Test (MAT) were used to gather data.

The data gathered were analyzed using *t*-test inferential statistics. The findings of the study revealed that there was: no significant difference in the performance of male and

female students in chemistry; significant difference in performance of students with high mathematical ability and low mathematical ability; and no significance difference in academic performance of male and female students with high mathematics ability in chemistry. The study concluded that gender does not have effect on students' performance in chemistry, however, mathematics ability does.

Olatoye, Aderogba, and Aanu (2011) investigated the influence of gender and self-concept on senior secondary school students' achievement in organic chemistry. The study adopted a quasi-experimental design of 3X2X2 factorial level where the experimental groups were exposed to cooperative and individualized teaching methods, the control group were taught using conventional method. The sample comprised of 52 students each (26 males and 26 females) randomly selected from three co-educational schools. Three instruments were used for data gathering: Chemistry Achievement Test (CAT); teaching manual; and Self-Concept Questionnaire (SCQ).

The data gathered were analyzed using ANCOVA at .05 level of significance. The findings of the study revealed that there was: a significant main effect of treatment on students' achievement in chemistry; no significant difference in students' achievement based on gender; self- concept did not have significant effect on achievement; no significant interaction effects of treatment and gender on students' achievement in chemistry; no significant interaction effects of treatment and self-concept on students' achievement in chemistry; no significant interaction effects of self-concept and gender on students' achievement in chemistry; and no significant interaction effects of treatment, self-concept and gender on students' achievement in chemistry.

Score levels and Students' Achievement in Chemistry

The rate of assimilation of principles of science differs from one student to another. Hence, the need to divide students based on the level at which they grasp science concepts becomes imperative. Thus, the practice of dividing students on basis of their perceived capacities for instruction is ability grouping or tracking (Adodo & Agbayewa, 2011). There have been several research studies conducted on how students are arranged within their classrooms. Science educators, as well as educational researchers have struggled to find out who benefit most when students are grouped based on their ability levels.

In every classroom, students are placed in groups, either based on their ability levels or randomly assigned by their teachers. The common practice in Nigerian classrooms is that students are either divided by alphabetical pairing; student's choice; or assigned to groups randomly irrespective of which ability level they belong. However, when students are placed in proper groups, students' ability to solve problem and think independently improves (Catalano, 2010), if alternatively, they are placed in a wrong group that doesn't fit their needs, their progress in learning might suffer. Ability grouping, on the other hand, is just another form of racial segregation. That is, when students are divided on the bases of ability, they are also divided by race and economic (Adodo & Agbayewa, 2011).

Leah (2015) investigated the influence of ability grouping on the learning of children from low income homes: a systematic review. The study explored the relationship between socio-economic status, ability grouping and children's educational outcomes which took a systematic review to examine available evidence which were selected by following specific set of inclusion criteria. The design for the study followed a literature based method of a systematic review which involves gathering available evidence specific to pre-assigned criteria. The inclusion criteria were date range from 2000 to 2015; written in English; an

empirical study design; participants from primary school children; participant analysis; use of grouping children b ability; and measuring of participant learning in these ability decided groups. Based on these criteria, only three studies were identified for analyses. The review indicated that children from lower income homes are more likely to be placed in lower ability grouping as the sole reason for the continuing attainment gap between less and more affluent children.

Jeroen and Ides (2014) examined educational tracking, inequality and performance. The purpose of the study was to investigate the effects of early tracking on students' achievement by making use of recent waves of internationally standardized students' assessment such as PISA, TIMSS and PIRLS. The study employed differences-in differences design and used a new set of combinations of recent students' assessment to determine the tracking effect. Performance scores in reading, mathematics and science from PIRLS, 2006-2011 and TIMSS 4th grade (2007-2011) were used as primary measurement points and TIMSS-8th grade (2007-2011) and PISA (2006- 2009) as the secondary points. The results showed consistently negative effects of early tracking on mean performance, showing strong negative effects on the group of low achievers.

The study of Adodo and Agbayewa (2011) examined the comparative effects of homogenous and heterogeneous ability grouping on students' interest, attitude and achievement in integrated science. The purpose of the study was to determine which of the grouping methods would produce high effect on students' achievement scores in integrated science. The study was a pretest-posttest and control group quasi experimental 2X3 factorial design where 60 randomly selected students from two junior secondary schools assigned to three ability levels of high; average; and low using numerical ability/word knowledge instrument were involved in the study. The data gathering instruments were: achievement test in integrated science (ATIS); science oriented attitudinal scale (SOAS); science vocational

interest inventory (SVII); and students' questionnaire on preference for grouping. These instruments were validated and found to be reliable with internal consistency values of 0.80, 0.65, and 0.80 for ATIS, SOAS, and SVII respectively.

The data gathered were analyzed using the mean, standard deviation and *t*-test statistics. The findings of the study revealed that: there was significant difference in the posttest mean scores of students in ATIS among the ability levels of homogenous and heterogeneous groups; there was significant difference in the attitude scores of the students among the ability levels of homogenous and heterogeneous class; and the reasons for non-preference of the heterogeneous group are in favor of the homogenous ability level class. The study concluded that homogenous ability grouping is superior for promoting students' achievement in their ability level.

Catalano (2010) investigated the influence of grouping students in the high school science settings. The purpose of the study was to examine the contribution of students' grouping in students' ability to create grade level appropriate laboratory reports and increase the students test average in their high school chemistry classroom. The sample for the study comprised of 62 third year students drawn from three different chemistry classrooms taught by the same teachers. The students' abilities were gauged using science skills pre-assessment test. Laboratory report format guide and laboratory report rubric were tools used for data gathering. The data gathered were analyzed using *t*-test inferential statistics and the finding of the study showed a significant increase in their test scores in all the three ability groups and there was a decrease in the number of behavioral problems and outbursts when the lower achieving students were paired with the higher achieving students.

Kang (2006) investigated the effects of classroom peers on academic achievement in science and mathematics. The purpose of the study was to examine the interactions among

classroom peers using quasi random assignment. The sample was 150 middle schools selected using stratified sampling involving two classes of grades 7 and 8 in which 15 to 20 students were randomly selected from each class. The third international mathematics and science study (TIMSS) was used to collect data. The data was analyzed with quantile regressions, and the findings revealed that; one's peer is positively correlated with a students' performance; weak students interacted more closely with other weak students than with strong students; and strong students also interacted with other strong students.

Venkatakrishnan and William (2003) conducted a study entitled tracking and mixed-ability grouping in secondary school mathematics classrooms. The study was carried out in an 11-16 co-educational comprehensive school in greater London in which three sets of students of; four mixed-track; three mixed-track; and one mixed ability groups were involved in the study. The data gathered were analyzed using ANCOVA. The findings of the study revealed that fast tracks students were not significantly advantaged by their placement in these tracks but the progress of students in the mixed ability group showed a significant interaction between progress and prior attainment, favoring the lower attaining students more and smaller disadvantage to higher attaining students.

Mariano and Kirby (2009) investigated the achievement of students in multi-grade classrooms. The study was based on panel data from the Los Angeles unified school district for students in grades 2 through 5 for six consecutive years from 2002-2007. The study adopted a quasi-experimental approach to examine the effect of being assigned to multi-grade classrooms on students' achievement. Propensity scoring techniques and doubly robust regression were used to estimate the counterfactual. Each subject was examined on five different multi-grade outcomes: 3rd graders in a grade 2-3configuration; 3rd and 4th graders in grade 3-4 configuration; 4th and 5th graders in a grade 4-5 configuration; and monograde students in the same grade as the multi-grade students served as a comparison group. The

findings revealed that 3rd, 4th and 5th grade students in multi-grade classrooms had average performance than expected had they been in a monograde classroom.

The influence of ability grouping on GCSE attainment was investigated by Ireson, Hallam and Hurley (2005). The aim of the study was to examine the effects of ability grouping on students' achievement in English, mathematics and science in general certificate of secondary education examinations (GCSE). The study was a longitudinal study of a cohort of about 6000 students selected using stratified sampling technique from 45 mixed secondary comprehensive schools. The achievement was measured from the results of national tests in English, mathematics and science obtained for students when in year 6 and year 9. The effects of setting on students' GCSE attainment in English, science and mathematics were explored using multilevel modeling. The finding of the study revealed setting or regrouping had little overall impact on GCSE attainment in English, mathematics or science, when prior attainment was statistically controlled.

Appraisal of the Reviewed Literature

Learning chemistry using ASEI-PDSI instructional strategy and its effects on senior school students' achievement, self-efficacy and attitudinal change was the focus of this study. The theoretical framework for the study is premised on information processing theory of Miller (1956) and Vygotsky's (1962, 1978) social development theory. These were linked to ASEI-PDSI classroom instruction which emphasizes collaboration among learners in providing solutions to task assigned by their instructor and sequentially processing and storing knowledge acquired.

The nature, contents and objectives of Nigerian Senior School chemistry curriculum were perused. Chemistry was found to be central to science as it bridges other natural sciences, including physics, geology and biology (Adebayo, 2008). Chemistry laboratory was

viewed as a place where scientific knowledge and technique are practiced. Therefore, encouraging activity-oriented instruction is imperative. It was also noted that 65% of the contents of the Nigeria senior school chemistry curriculum were perceived difficult by Nigerian Senior School students (Uchegbu, et al 2016; Ugwu, 2014).

Studies reviewed on ASEI-PDSI instructional strategy examined the extent of practice and classroom implementation of ASEI-PDSI instruction (Ateigo *et al.*, 2015; Kiige & Atina, 2016; Ndirangu, 2017; Odhiambo, 2016). Teachers' and students' attitude towards implementation of ASEI-PDSI were the major focus of these studies and all the studies employed descriptive research of the survey type in Kenya. The studies of Adamu (2017); Barasa, (2015); Mwelese and Atwoto, (2014) were similar to the present study because their studies examined the influence of ASEI-PDSI instructional strategy on students' achievement. However, the study of Barasa (2015) was a survey type.

The studies of Adamu (2017) and Mwelese and Awoto (2014) on effects of ASEI-PDSI were carried out in the area of mathematics. Although, Adamu's (2017) study focused on Nigerian Basic School pupils. However, Mwelese and Awoto (2014) examined the influence of ASEI-PDSI on students' achievement, views and attitude towards mathematics in Kenya and employed true experimental design and the work was hinged on information processing theory. This present study however, adopted quasi-experimental design; combined information processing theory with constructivism as the framework for the study; and examined the effectiveness of SEI-PDSI instructional strategy on all of achievement, self-efficacy and attitude towards chemistry in Ilorin, Nigeria.

The studies of Abulude (2016), Khan and Ali (2012) concluded that students had negative attitude towards chemistry. However, the study of Kenar, *et al.* (2015), disagreed, and indicated that students had positive attitude towards chemistry. Similarly, significant

correlation between achievement and attitude towards chemistry was reported (Mogane, 2010). The studies of Tuyuz (2010), Festus and Ekpete (2012) were different from the earlier studies, as they were both quasi- experimental researches. Their findings claimed that appropriate methods of instruction may enhance achievement, and thus, induce positive attitudinal change in students. Hence, this study investigated further, so as to accept or refute these claims.

Studies reviewed on self-efficacy and achievement in chemistry revealed a significant correlation between these variables and that, self-efficacy contributed better than other variables such as attitude, self-regulated learning and so on, to students' learning (Ahmed, 2012; Akomolafe, Ogunmakin & Fassoto, 2013; Ferrell & Barbera, 2015; Gracia, 2010; Tenaw, 2013). However, the study of Baanu, Oyelekan and Olorundare (2016) reported no significant correlation between self-efficacy and achievement in chemistry. Similarly, the studies of Mari and Gumel (2015), Nbina (2010) were experimental studies that posited that self-efficacy may be enhanced through the use of appropriate instructional strategies. Hence, this study further investigated, in order to agree or disagree with this claim.

Studies reviewed on the influence of gender on students' achievement, self-efficacy and attitudes toward science were inconclusive. The studies of Cheung (2009), Olatoye, Aderogba and Aanau (2011), Udousoro (2011) showed no significant gender difference in achievement and attitude towards chemistry. However, the studies of Aniodoh and Egbo (2013), Heng and Karpudewan (2014), showed statistically significant difference in achievement, self-efficacy and attitudes toward science based on gender, favoring the female students.

Similarly, studies reviewed on influence of gender were either on achievement in chemistry, or attitude towards chemistry. However, in this study, the researcher examined the

influence of gender on all of achievement, self-efficacy and attitude towards chemistry and confirmed the influence of gender on these variables.

Studies on score levels and achievement, self-efficacy and attitudes toward science showed varying results from researchers. The studies of Adodo and Agbayewa (2011), Leah (2015), Jeroen & Ides (2014), revealed that grouping of students based on score levels showed consistently negative effects of early tracking on mean performance and strong negative effects on the group of low achievers. The studies of Catalano (2010), Kang (2006), Mariano & Kirby (2009) revealed that the progress of students in the mixed ability group showed a significant interaction between progress and prior attainment, favoring the lower attaining students more and smaller disadvantage to higher attaining students.

From all studies available to the researcher, there have not been experimental study on ASEI-PDSI instructional strategy in the Senior Schools, specifically, in Nigeria. Hence, this study therefore, investigated the effects of ASEI-PDSI instructional strategy on students' achievement, self-efficacy and attitude towards chemistry. Considering the ASEI-PDSI instructional strategy as the independent variable, achievement, self-efficacy and attitude as dependent variables, while gender and score levels of students were the moderating variables.

CHAPTER THREE

RESEARCH METHOD

This chapter presents procedures employed in conducting the study under the following subheadings: research design; population; sample and sampling technique; research instrument; validation of research instruments; procedure for data collection; and data analysis techniques.

Research Design

The study adopted 2 x 2 x 3 quasi-experimental research design involving pretest, posttest, non-randomized control groups. The first 2 represents the experimental and the control groups; the next 2 represents the students' gender, also at two levels of male and female; while the 3 represents students' score levels of low, medium and high. Also, in this study, intact classes of the students were involved so as to avoid distortion of the regular school program and to control for selection bias.

The experimental and control groups were exposed to pre-test, pre-treatment self-efficacy test, and pre-treatment attitude test and the corresponding post-test, post-treatment self-efficacy, and post-treatment attitude. These pre and post treatments, are the dependent variables of achievement, self-efficacy and attitude in this study.

The design symbol is as follows

Experimental group:	O_1	X	O_4
	O_2		O_5
	O_3		O_6
	- -- - - - - - - -- - - -		
Control group :	O_1		O_4

O_2 O_5

O_3 O_6

KEY:

O_1- pretest on achievement for the groups

O_2 - pre-treatment self-efficacy test for the groups

O_3 - Pre-treatment attitude test for the groups

X – Treatment for experimental group

O_4- post-test on achievement for the groups

O_5- post-treatment self-efficacy test for the groups

O_6- Post-treatment attitude test for the groups

Population, Sample and Sampling Techniques

The population for this study was all Senior Secondary School students in Ilorin, Nigeria; while the target population was all first year Senior School students (SSI) offering chemistry in Ilorin. The choice of SSI as the target population was based on the fact that SSI is the introductory class to chemistry as a subject, hence developing positive attitude towards chemistry at this first year, is imperative. Also, the content scope of acids, bases and salts are usually taught at the first year in most Senior Secondary Schools in Nigeria.

There are seventy-eight (78) public Senior Schools in Ilorin, Nigeria. Out of these 78 schools, seven (7) schools are not co-educational, thus, they were exempted from the study. Four (4) schools with qualified chemistry teachers which have been presenting candidates for Senior School Certificate Examinations (SSCE) for at least ten years, and not situated close

to one another were selected from the remaining 71 schools in Ilorin using simple random sampling technique. The sampled schools were randomized into experimental and control groups and their intact classes were involved in this study with a total sample size of 292 students (138 males and 154 females).

Research Instruments

Four instruments were used in gathering data in this study namely:

i. The ASEI Instructional Package (ASEI-IP);
ii. Acids, Bases & Salts Achievement Test, (ABSAT);
iii. Attitude Towards Chemistry Scale, (ATCS); and
iv. Chemistry Self-Efficacy Scale (CSES)

The ASEI Instructional Package (ASEI-IP) was a stimulus instrument that is made up ASEI activity sheet, the ASEI lesson plan, ASEI interaction plan, and ASEI chalkboard plan for the experimental group. The ASEI activity sheet provided the students with step-by-step procedures to employ during instruction, the ASEI lesson plan showed the intended lesson objectives and procedures in achieving the stated objectives through relevant class activities. The ASEI interaction plan contained the types of questions to be asked by the teacher, the expected responses from the students and the questioning techniques at each stage of the lesson. The ASEI chalkboard plan showed the logical flow of the lesson, corresponding to each step of the lesson plan (Appendices VI, VII, VIII, & IX).

The Acids, Bases & Salts Achievement Test, (ABSAT) was a researcher designed test with items structured to test students' knowledge, comprehension, application, analysis, synthesis and evaluation levels of acids, bases and salts based on Bloom's taxonomy of

educational objectives. The ABSAT comprised twenty (20) multiple choice questions with options lettered A-D and seven (7) open-ended questions. See Appendix I

The Attitude Towards Chemistry Scale, (ATCS) was a questionnaire designed to measure students' attitude towards chemistry. The ATCS consisted twenty (10 positive & 10 negative) statements with responses on a 4-point Likert scale of strongly agree (SA); agree (A); disagree (D); and strongly disagree (SD). The ratings ranged from Strongly Agree (4) to Strongly Disagree (1) for the positive statements and the reverse ratings, Strongly Agree (1) to Strongly Disagree (4) were used for the negative statements. The scores from the ATCS ranged from the lowest, 20 (25%) to the highest, 80 (100%). In this study, students with scores below (50) 62.5% were adjudged to have negative attitude.

The attitude towards chemistry lesson scale, ATLC (Cheung, 2009) were adapted and modified to develop the ATCS in this study (Appendix II). The modifications made were to reduce the response modes from 7-point likert to 4-point likert and some items were changed into negative statements. This was necessitated in order to reduce the effects of acquiescence and other response biases

The Chemistry Self-Efficacy Scale, (CSES) consisted ten (10) statements on students' perceived self-efficacy on acids, bases and salts with responses on a 4-point Likert ranging from strongly agree (4) to strongly disagree (1). The scores from the CSES ranged from the lowest,10 (25%) to the highest, 40 (100%) and any score below 62.5% were considered to possess low self-efficacy. The CSES was the modified version of the college chemistry self-efficacy scale (CCSES) of Uzuntiryaki and Aydin (2009).

The CCSES was used to measure students' self-efficacy on chemistry as whole. However, the CSES in this study measured students' perceived self- efficacy on acids, bases and salts only. Other modifications made include changing the response modes from very

poorly, poorly, well, and very well to strongly disagree, disagree, agree and strongly agree respectively in the believe that the response modes better represent respondents' personal opinions. This change was also necessitated due to transformation of items in the CCSES from questions to statements.

Validation of Research Instruments

The instruments were given to two experts in Science Education Department, University of Ilorin, Nigeria; two experienced Senior School chemistry teachers; a senior lecturer in the Department of Chemistry, University of Ilorin; and to my supervisor for both face and content validity. This ensured that these instruments were appropriate and the items measured what they were designed to measure.

Consequently, the item analysis of ABSAT was conducted, where the difficulty and discrimination indices were calculated for items in the multiple choice. This was to ensure that these items were not too difficult nor too easy; and spread across different knowledge levels of the students. The initial draft of 25 items were administered to SSI students in a non-participating school in Ilorin. However, 5 items were discarded because the difficulty indices were below 0.5. Similarly, items 4, 9, 13, 17 and 18 were modified and thus, the final draft comprised 20 multiple choice items.

Also, in order to ascertain the internal consistencies of ABSAT, ATCS, and CSES, these instruments were trial tested. A test-retest reliability method was employed involving 20 non-participating SSI students in Ilorin with an interval of two weeks between the first and the second test. The resulting data from ABSAT were analyzed using Kuder-Richardson formula 20, KR-20 while Cronbach's alpha was used to analyze ATCS and CSES. The reliability coefficients of ABSAT, ATCS and CSES were found to be 0.76, 0.68 and 0.73 respectively. Hence, these instrument were adjudged to be reliable.

Procedure for Data Collection

A letter of introduction was collected from the Head of Department, Science Education Department, University of Ilorin, Nigeria by the researcher and presented to the principals of the sampled schools. This was to seek their permissions and consents to involve their schools, teachers and allow their students to take part in the study. The researcher interacted with the chemistry teachers, enlightened and acquainted them with the nature of the study and thus, formally sought their consents through the informed consent forms, to serve as research assistants for this study.

Also, the researcher met with the students and apprised them of the significance and benefits of the study to their academic pursuits. Similarly, the researcher affirmed and disclosed to the students that: the data obtained from the study is strictly for research purpose; their identity would be treated with utmost confidentiality; the study would not be forced on them; and they may withdraw their participation at any stage of the study. Hence, formally sought for their consents and that of their parents through filling of the informed consent forms.

The researcher revisited the sampled schools to retrieve the informed consent forms and ascertained the participation status of the subjects of the study. The research assistants for the experimental group received a special training on how to use ASEI-IP and were provided with training manual for reference purpose (appendix IX). The experimental group was taught with ASEI-IP while the control group was taught without using ASEI-IP. The ATCS, CSES, and ABSAT were administered as pre-treatment attitude test, pre-treatment self-efficacy test and pretest respectively. This was to measure students' attitude, self-efficacy and weaknesses prior to the treatment. The ATCS was administered first, followed by CSES and

then, the ABSAT. The order ATCS – CSES – ABSAT became imperative so as to avoid ABSAT having negative influence on the results of ATCS and CSES.

Six periods of forty minutes lesson were used in each of the schools for administration of treatments. The control group was taught using the regular strategies adopted by their teachers. However, the students in the experimental group worked cooperatively in a group of seven, where each member of a group had specific task assigned and interacted with the materials provided, and the ASEI-activity sheet served as guide to reaching the lesson objectives. The researcher and the research assistants only facilitated the learning process in this group. Thereafter, the ABSAT, ATCS and CSES were administered respectively after the treatment as posttest, post-treatment attitude test and post-treatment self-efficacy test.

Data Analysis Techniques

The data gathered were analyzed using descriptive and inferential statistics. Demographic data of the respondents was analyzed using the percentage and frequency. Each research question has a corresponding hypothesis, hence testing these hypotheses answer the research questions. Hypotheses 1, 2, 3, 7, 8, 9, 10, 11 and 12 were tested using Analysis of Covariance (ANCOVA). The choice of ANCOVA was considered appropriate for these hypotheses because the pretest, pre-treatment self-efficacy, and pre-treatment attitude served as covariates and the groups were not randomized. Hypotheses 3, 4 and 5 were tested using independent *t*-test statistic because there was no overlap between the two groups, the data are continuous, and the samples contained homogenous variances. These statistical analyses were done using Statistical Package for Social Sciences, SPSS 22.0 window version.

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

This chapter presents analyses and interpretation of data collected through the Acids, Bases and Salts Achievement Test (ABSAT), Chemistry Self-Efficacy Scale (CSES) and Attitude Towards Chemistry Scale (ATCS). As shown in Table 2, there are 292 valid subjects with total of 138 male and 154 female participants in both groups. The experimental group exposed to ASEI-PDSI instructional strategy comprised 153 (83 males, 70 females) subjects while control group that was not exposed to ASEI-PDSI instructional strategy comprised 139 (55 males, 84 females) subjects. The distribution of the subjects based on score levels shows that the sample comprised 105, 74, and 113 low, medium and high scorers respectively in both groups.

Table 2

Demographic Data of the Subjects

Group		Gender		Score Levels			Total
		Male	Female	Low	Medium	High	
Experimental	f	83	70	60	42	51	153
	%	54.2	45.8	39.2	27.5	33.3	100.0
Control	f	55	84	45	32	62	139
	%	39.6	60.4	32.4	23.0	44.6	100.0
Total	f	138	154	105	74	113	292
	%	47.3	52.7	36.0	25.3	38.7	100.0

H_{01}: There is no significant difference in the achievement of students exposed to ASEI-PDSI instruction and those not exposed to ASEI-PDSI instruction

In order to test hypothesis one, Table 3 showed the arithmetic mean of students' posttest scores in the control and experimental groups as $\bar{x}$=11.52 and 25.36 respectively. Consequently, these mean scores were compared in Table 4 where Analysis of Covariance (ANCOVA) was performed to determine whether a significant difference existed between the mean scores. The result of ANCOVA reveals *p*-value of .00 computed at .05 alpha level

($F_{(1,289)}$= 238.24, p<.05). Since the p-value obtained was less than the alpha value .05, thus, hypothesis one was rejected. This implies that there was a significant difference in the achievement of students exposed to ASEI-PDSI instruction (experimental) and those not exposed to the ASEI-PDSI instruction (control).

A follow-up Bonferroni post hoc test was conducted in Table 5 to ascertain the actual direction of the difference that existed between the groups and this revealed a mean difference of 12.36 at p < .05. This was in favour of the experimental group. Hence, the experimental group performed significantly better than their control counterparts

Table 3

Mean and Standard Deviation of Achievement Test by Groups

Groups	N	Tests	Mean	Std. Deviation	Remark
Control	139	Pre-test	6.27	2.56	Low
		Posttest	11.52	4.08	Fair
Experimental	153	Pre-test	6.19	2.46	Low
		Posttest	25.03	5.02	High

Table 4

Analysis of Covariance for Difference between Group Means in Achievement Test

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	6968.55[a]	2	3484.27	189.34	.00	.74
Intercept	3507.40	1	3507.40	190.60	.00	.58
Pretest	382.71	1	382.71	20.79	.00	.13
Group	4383.94	1	4383.94	238.24	.00	.64
Error	2502.59	289	18.40			
Total	60643.00	292				
Corrected Total	9471.13	291				

a. R Squared = .73 (Adjusted R Squared = .73)

Table 5

Bonferroni Post-Hoc Test on Students' Achievement between Groups

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Control	Experimental	-12.36*	.80	.00	-13.95	-10.78
Experimental	Control	12.36*	.80	.00	10.78	13.95

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni

H_{02} There is no significant difference in the self-efficacy of students exposed to ASEI-PDSI and those not exposed to ASEI-PDSI instructional strategy

Also, testing hypothesis two requires comparing the mean scores of post-self-efficacy test of the two groups. Hence, Table 6 presents the arithmetic mean of students' scores in post-self-efficacy test in the control and experimental groups as $\bar{x}$ =25.79 and 28.73 respectively. These mean scores were compared in Table 7 where Analysis of Covariance (ANCOVA) was performed to determine whether a significant difference existed between the mean scores. The result of ANCOVA showed *p*-value of .00 computed at .05 alpha level ($F_{(1,289)}$= 15.32, p< .05). Since the *p*-value was less than the alpha value of .05, thus, hypothesis two was rejected. This implies that a significant difference in the self-efficacy of students exposed to ASEI-PDSI instructional strategy (experimental) and those not exposed to the ASEI-PDSI instructional strategy (control).

A follow-up Bonferroni post hoc test was conducted in Table 8 to determine the actual direction of the difference that existed between the groups. It reveals a mean difference of 3.09 at p< .05 in favour of the experimental group. This implies that the experimental group had higher self-efficacy than their counterparts in the control group

Table 6

Mean and Standard Deviation of Self-Efficacy Test by Groups

Groups	N	Tests	Mean	Std. Deviation	Remark
Control	139	Pre-test	26.37	6.22	Fair
		Posttest	25.79	5.92	Fair
Experimental	153	Pre-test	26.23	4.64	Fair
		Posttest	28.68	3.82	Better

Table 7

Analysis of Covariance for Difference between Group Means in Self-Efficacy Test

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	789.86[a]	2	394.93	18.39	.00	.21
Intercept	1768.83	1	1768.83	82.39	.00	.38
Pre-Self-efficacy	493.61	1	493.61	22.99	.00	.15
Group	328.75	1	328.75	15.31	.00	.10
Error	2919.94	289	21.47			
Total	108197.00	292				
Corrected Total	3709.799	291				

a. R Squared = .213 (Adjusted R Squared = .201)

Table 8

Bonferroni Post-Hoc Test on Students' Self-Efficacy between Groups

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Control	Experimental	-3.097*	.791	.000	-4.662	-1.532
Experimental	Control	3.097*	.791	.000	1.532	4.662

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

H_{03}: There is no significant difference in the attitude of students exposed to ASEI-PDSI and those not exposed to ASEI-PDSI instructional strategy

To test hypothesis three, the post-attitude test of both groups were also compared and their pre-test served as covariate. In Table 9, the arithmetic mean of students' scores in post-attitude test for the control and experimental groups are $\bar{x}$=54.52 and 59.10 respectively. These values are a little above the benchmark of 50 that was set for positive attitude in this study. However, these mean scores were compared in Table 10 where Analysis of Covariance (ANCOVA) was performed to determine whether a significant difference existed between the mean scores. The result of ANCOVA revealed *p*-value of 0.14 computed at .05 alpha level ($F_{(1,289)}$= 2.25, p>.05). Since the *p*-value obtained was greater than .05 alpha level, therefore, hypothesis three was not rejected. It implies that no significant difference existed in the attitude of students exposed to ASEI-PDSI instructional strategy (experimental) and those not exposed to the ASEI-PDSI instructional strategy (control) even though, the experimental group scored higher in the attitude test.

Table 9

Mean and Standard Deviation of Attitude Test by Groups

Groups	N	Tests	Mean	Std. Deviation	Remark
Control	139	Pre-test	52.39	6.73	Fair
		Posttest	54.52	6.50	Fair
Experimental	153	Pre-test	52.23	6.17	Fair
		Posttest	59.10	7.92	Better

Table 10

Analysis of Covariance for Difference between Group Means in Attitude Test

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	2302.03[a]	2	1151.02	28.09	.00	.29
Intercept	1272.55	1	1272.55	31.05	.00	.19
Pre-Attitude	1486.30	1	1486.30	36.27	.13	.01
Group	92.28	1	92.28	2.25	.14	.02
Error	5573.49	289	40.98			
Total	462913.00	292				
Corrected Total	7875.53	291				

a. R Squared = .29 (Adjusted R Squared = .28

H_{04}: There is no significant difference in achievement of male and female students exposed to ASEI-PDSI instructional strategy.

To test hypothesis four for a significant difference in achievement of male and female students exposed to ASEI-PDSI instructional strategy (experimental), independent sample *t*-test was employed for both pre and posttests. Table 11 shows *t*-test analysis of difference in pretest achievement of male and female students exposed to ASEI-PDSI instructional strategy and revealed *p*-value of 0.04 which was less than .05 alpha level ($t_{(151)}$=3.17, p< .05). This implies that there was a significant difference in the achievement of male and female students before they were exposed to the treatment. On the other hand, Table 12 shows the result of *t*-test analysis performed on the difference in posttest and revealed *p*-value of 0.11 which was greater than .05 alpha level ($t_{(151)}$=1.62 p >.05). Hence, hypothesis four was not rejected. This implies that there was no significant difference in the achievement of male and female students after they were exposed to ASEI-PDSI instructional strategy.

Table 11

The t-test Analysis for Difference between Male and Female Students' Mean Scores in Pre-Test

Experimental Gender	No.	Mean	SD	df	*t*	Sig.	Decision
Male	83	6.43	3.69	151	3.17	.04	Significant
Female	70	9.37	3.22				

P<.05

Table 12

The t-test Analysis for Difference between Male and Female Students' Mean Scores in Post-Test

Experimental Gender	No.	Mean	SD	df	*t*	Sig.	Decision
Male	83	26.19	5.07	151	1.62	.109	Not Significant
Female	70	24.37	4.70				

P>.05

H_{05}: There is no significant difference in self-efficacy of male and female students exposed to ASEI-PDSI instructional strategy.

To test hypothesis five, independent sample *t*-test was also employed for both pre-self-efficacy and post-self-efficacy tests. Table 13 shows *t*-test analysis of difference in pre-self-efficacy test of male and female students exposed to ASEI-PDSI instructional strategy and reveals thus ($t_{(151)}$=2.09, p<.05). This implies that a significant difference existed in the self-efficacy of male and female students before they were exposed to the treatment. In the same vein, Table 14 shows the result of *t*-test analysis performed on the difference in posttest and reveals that *p*-value of .01 less than .05 alpha level ($t_{(151)}$=2.70, p<.05). since the *p*-value was less than the alpha value, then, hypothesis five was rejected. This implies that, a significant difference existed in the self-efficacy of male and female students after they were exposed to ASEI-PDSI instructional strategy.

Table 13

The t-test Analysis for Difference between Male and Female Students' Mean Scores in Pre-Self-Efficacy Test

Experimental Gender	No.	Mean	SD	df	*t*	Sig.	Decision
Male	83	26.88	3.67	151	2.09	.04	Significant
Female	70	24.77	4.17				

Table 14

The *t-test Analysis for Difference between Male and Female Students' Mean Scores in Post-Self-Efficacy Test*

Experimental Gender	No.	Mean	SD	df	*t*	Sig.	Decision
Male	83	29.83	4.07	151	2.70	.01	Significant
Female	70	27.40	3.77				

P<.05

H_{06}: There is no significant difference in attitude of male and female students exposed to ASEI-PDSI instructional strategy.

Hypothesis six was tested with independent sample *t*-test. This was to determine whether a significant difference existed in the pre and post attitude tests of male and female students exposed to ASEI-PDSI instructional strategy. Thus, Table 15 shows *t*-test analysis of difference in pre-attitude test of male and female students exposed to ASEI-PDSI instructional strategy and revealed ($t_{(151)}$=1.06, p>.05). This implies that no significant difference existed in the attitude of male and female students before they were exposed to the treatment. similarly, Table 16 shows the result of *t*-test analysis performed on the difference in post-attitude test and revealed *p*-value of 0.13 which was greater than the .05 alpha level, ($t_{(151)}$=1.64, p>.05). since the *p*-value was greater than the alpha level, hypothesis six, was

therefore, not rejected. This implies that there was no significant difference in the attitude of male and female students after they were exposed to ASEI-PDSI instructional strategy.

Table 15

The t-test Analysis for Difference between Male and Female Students' Mean Scores in Pre-Attitude Test

Experimental Gender	No.	Mean	SD	df	*t*	Sig.	Decision
Male	83	59.17	5.02	151	1.06	.29	Not Significant
Female	70	56.69	6.25				

P>.05

Table 16

The t-test Analysis for Difference between Male and Female Students' Mean Scores in Post-Attitude Test

Experimental Gender	No.	Mean	SD	df	*t*	Sig.	Decision
Male	83	60.24	7.40	151	1.64	.13	Not Significant
Female	70	58.37	7.99				

P>.05

H_{07}: There is no significant difference in achievement of low, medium, and high scorers exposed to ASEI-PDSI instructional strategy.

In order to test hypothesis seven, Analysis of Covariance was employed. The results of the analysis on Table 17 suggests that a significant difference existed in the achievement of low, medium and high scorers exposed to ASEI-PDSI instructional strategy with *p*-value of 0.00 which was less than .05 alpha level. That is, ($F_{(2,149)}$= 5.90, p<.05), hence, hypothesis seven was rejected. In the same vain, to ascertain where the difference lies, a Bonferroni post hoc test was conducted and reported in Table 18. Table 18 reveals that, a significant

difference only existed in the achievement the high and low scorers (p<.05). On the other hand, no significant difference existed between low and medium; and medium and high (p>.05). Hence, low and medium scorers were favoured.

Table 17

Analysis of Covariance of Students' Score Levels in Achievement Test

Source	TypeIII Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	305.25[a]	3	101.75	4.62	.01	.16
Intercept	879.80	1	879.80	39.90	.00	.35
Pre-test	21.46	1	21.46	.97	.00	.51
Score Levels	19.29	2	9.65	5.90	.00	.14
Error	1631.62	149	22.05			
Total	51692.00	153				
Corrected Total	1936.87	152				

a. R Squared = .16 (Adjusted R Squared = .12)

Table 18

Bonferroni Post-Hoc Test on Students' Score Levels in Achievement Test

(I) Score Levels	(J) Score Levels	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Low	Medium	-1.09	1.31	1.00	-4.30	2.13
	High	-4.24*	1.27	.00	-7.35	-1.13
Medium	Low	1.09	1.31	1.00	-2.13	4.30
	High	-3.15	1.34	.06	-6.42	.12
High	Low	4.24*	1.27	.00	1.13	7.35
	Medium	3.15	1.34	.06	-.12	6.42

Based on observed means.
The error term is Mean Square(Error) = 21.77.

H_{08}: There is no significant difference in self-efficacy of low, medium, and high scorers exposed to ASEI-PDSI instructional strategy.

Analysis of Covariance was employed to test hypothesis eight and the results of the analysis on Table 19 reveals that no significant difference existed in the self-efficacy of low, medium and high scorers exposed to ASEI-PDSI instructional strategy with *p*-value of 0.84 which was greater .05 alpha level. That is, ($F_{(2,149)}$= 0.18, *p*>.05), hence, hypothesis eight was not rejected. This implies that the self-efficacy of low, medium and high scorers was not statistically different after they were exposed to the treatment.

Table 19

Analysis of Covariance of Students' Score Levels in Self-Efficacy Test

Source	TypeIII Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	211.92[a]	3	70.64	4.85	.00	.17
Intercept	819.12	1	819.12	56.23	.00	.44
Pre-Self-Efficacy	202.86	1	202.86	13.93	.00	.16
Score Levels	5.11	2	2.56	.18	.84	.01
Error	1063.35	149	14.57			
Total	64820.00	153				
Corrected Total	1275.27	152				

a. R Squared = .17 (Adjusted R Squared = .13)

H_{09}: There is no significant difference in attitude towards chemistry of low, medium, and high scorers exposed to ASEI-PDSI instructional strategy.

Similarly, ANCOVA was also employed in testing hypothesis nine. And the results of the analysis on Table 20 reveals that no significant difference existed in the attitude of low, medium and high scorers exposed to ASEI-PDSI instructional strategy, owing to *p*-value of 0.28 which was greater than .05 alpha level. That is, ($F_{(2,149)}$= 1.30, *p*>.05), hence, hypothesis

nine was not rejected. This implies that the attitude towards chemistry of low, medium and high scorers was not statistically different after they were exposed to the treatment.

Table 20

Analysis of Covariance of Students' Score Levels in Attitude Test

Source	TypeIII Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	982.70[a]	3	327.57	6.82	.00	.22
Intercept	397.46	1	397.46	8.28	.01	.10
Pre-Attitude	904.82	1	904.82	18.84	.00	.21
Score Levels	125.09	2	62.54	1.30	.28	.03
Error	3505.61	149	48.02			
Total	276077.00	153				
Corrected Total	4488.31	152				

a. R Squared = .22 (Adjusted R Squared = .19)

H_{010}: There is no significant interaction among achievement, gender and score levels of students exposed to ASEI-PDSI instructional strategy

In testing hypothesis ten, ANCOVA was employed. The analysis on Table 21 and the illustration on Figure 5 suggest no significant interaction among achievement in the ABSAT, gender and score levels of students exposed to ASEI-PDSI instructional strategy. That is, ($F_{(2,149)}$= 0.55, p>.05), thus, hypothesis ten was not rejected. This implies that, the difference in the performance of students exposed to ASEI-PDSI instructional strategy was not influenced by their gender nor their respective score levels. Hence, it was solely as a result of the intervention provided.

Table 21

Result of Analysis of Covariance Showing Interaction Effects among Achievement, Gender and Score Levels of students exposed to ASEI-PDSI Instructional Strategy

Source	TypeIII Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	447.51[a]	6	74.58	3.56	.00	.23
Intercept	818.73	1	818.73	39.03	.00	.36
Pre-test	23.62	1	23.62	1.13	.29	.02
Score Levels	42.71	2	21.35	1.02	.01	.03
Gender	128.40	1	128.40	6.12	.22	.08
Score Levels* Gender	22.93	2	11.47	.55	.58	.02
Error	1489.37	146	20.98			
Total	51692.00	153				
Corrected Total	1936.872	152				

a. R Squared = .231 (Adjusted R Squared = .166)

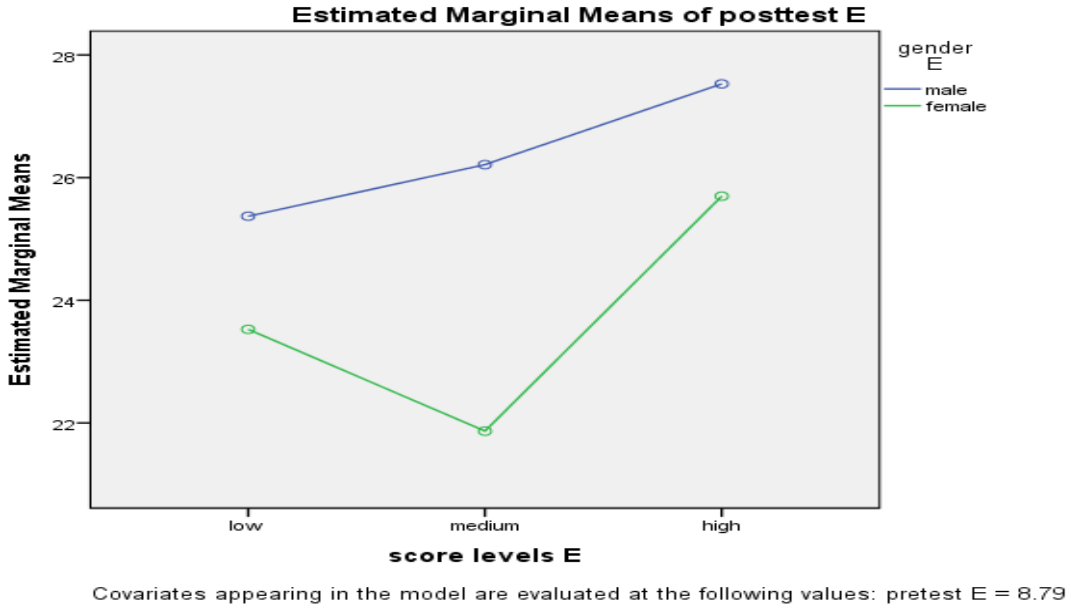


Figure 5: *Graphical Representation of Interactions among Achievement, Gender and Score Levels of students exposed to ASEI-PDSI Instructional Strategy*

H_{011}: There is no significant interaction among attitude towards chemistry, gender and score levels of students exposed to ASEI-PDSI instructional strategy

ANCOVA was employed to test hypothesis eleven and the analysis on Table 22 and the illustration on Figure 6 suggest there was no significant interaction among attitude towards chemistry, gender and score levels of students exposed to ASEI-PDSI instructional strategy. That is, ($F_{(2,146)}$=.23, p>.05), thus, hypothesis eleven was not rejected. This implies that difference in the self-efficacy of students exposed to ASEI-PDSI instructional strategy was neither influenced by their gender nor their respective score levels. Hence, it was solely as a result of the intervention provided.

Table 22

Results of Analysis of Covariance Showing Interaction Effects among Self-Efficacy, Gender and Score Levels of students exposed to ASEI-PDSI Instructional Strategy

Source	TypeIII Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	283.89[a]	6	47.32	3.34	.01	.22
Intercept	880.36	1	880.36	62.16	.00	.47
Pre-Self-Efficacy Test	134.36	1	134.36	9.49	.00	.12
Score Levels	61.95	1	61.95	4.37	.04	.06
Gender	16.45	2	8.23	.58	.56	.02
Score Levels* Gender	6.54	2	3.27	.23	.80	.01
Error	991.38	146	14.16			
Total	64820.00	153				
Corrected Total	1275.27	152				

a. R Squared = .22 (Adjusted R Squared = .16)

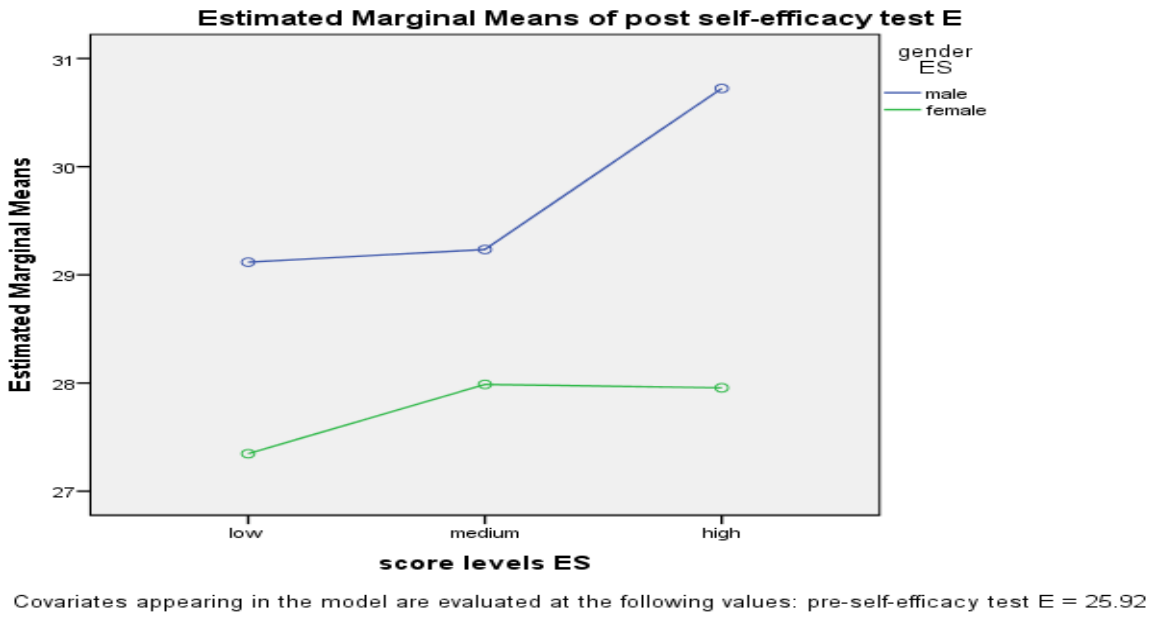


Figure 6: *Graphical Representation of Interactions among self-efficacy, Gender and Score Levels of students exposed to ASEI-PDSI Instructional Strategy*

H_{012}: There is no significant interaction among achievement, gender and score levels of students exposed to ASEI-PDSI instructional strategy

ANCOVA was also employed to test hypothesis twelve and the analysis on Table 23 suggests there was no significant interaction among attitude towards chemistry, gender and score levels of students exposed to ASEI-PDSI instructional strategy. That is, ($F_{(2,146)}$=0.96, p>.05). In contrast, Figure 7 suggests that there was interaction between gender and the score levels, although, not statistically significant. Hence, hypothesis twelve was not rejected. This implies that gender and score levels of students could have interacted with their change in attitude towards chemistry. hence, contributed to the statistical insignificance.

Table 23

Result of Analysis of Covariance Showing Interaction Effects among Attitude, Gender and Score Levels of students exposed to ASEI-PDSI Instructional Strategy

Source	TypeIII Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	1076.72[a]	6	179.45	3.68	.00	.24
Intercept	418.14	1	418.14	8.58	.00	.11
Pre-test	768.29	1	768.29	15.76	.00	.18
Score Levels	.76	1	.76	.02	.90	.00
Gender	107.92	2	53.96	1.11	.34	.03
Score Levels* Gender	93.58	2	46.79	.96	.39	.03
Error	3411.59	146	48.74			
Total	276077.00	153				
Corrected Total	4488.31	152				

a. R Squared = .240 (Adjusted R Squared = .175)

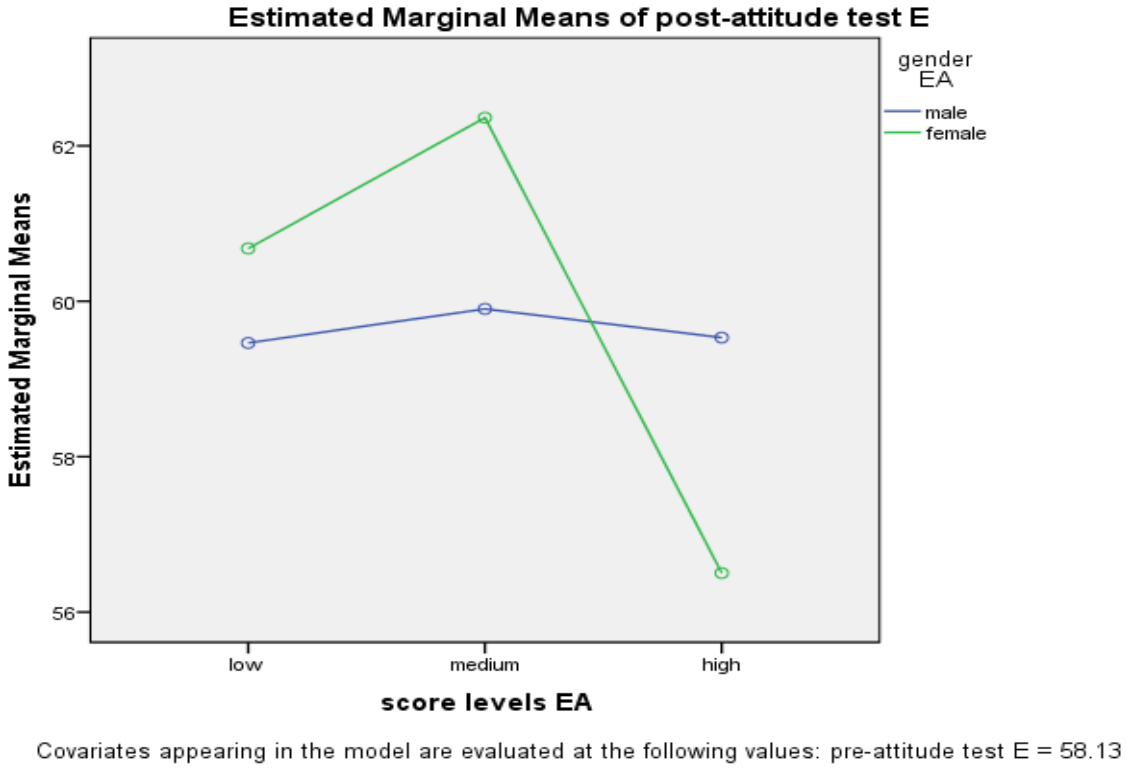


Figure 7: *Graphical Representation of Interactions among Achievement, Gender and Score Levels of students exposed to ASEI-PDSI Instructional Strategy*

Summary of Major Findings

From the preceding analyses and interpretations, the following are the major findings from the study:

i. There was significant difference in the achievement of students exposed to ASEI-PDSI instructional strategy (experimental) and those not exposed to ASEI-PDSI instructional strategy (control), which was in favour of the experimental group ($F_{(1,289)}$= 238.24, p< .05);

ii. There was significant difference in the self-efficacy of students exposed to ASEI-PDSI instructional strategy (experimental) and those not exposed to ASEI-PDSI instructional strategy (control), which was in favour of the experimental group ($F_{(1,289)}$= 2.25, p<.05);

iii. There was no significant difference in the attitude of students exposed to ASEI-PDSI instructional strategy (experimental) and those not exposed to ASEI-PDSI instructional strategy (control);

iv. There was no significant difference in the achievement of male and female students exposed to ASEI-PDSI instructional strategy;

v. A significant difference existed in the self-efficacy of male and female students exposed ASEI-PDSI instructional strategy, in favour of the male students ($t_{(151)}$=2.09, p<.05);

vi. No significant difference existed in the attitude of male and female students exposed ASEI-PDSI instructional strategy;

vii. A significant difference existed in the achievement of low, medium and high scorers exposed to ASEI-PDSI instructional strategy, in favour of the low scorers. That is, ($F_{(2,149)}$= 5.90, p<.05);

viii. No significant difference existed in the self-efficacy of low, medium and high scorers exposed to ASEI-PDSI instructional strategy;

ix. No significant difference existed in the attitude of low, medium and high scorers exposed to ASEI-PDSI instructional strategy;

x. There was no significant interaction among achievement, gender and score levels of students exposed to ASEI-PDSI instructional strategy;

xi. There was no significant interaction among self-efficacy, gender and score levels of students exposed to ASEI-PDSI instructional strategy;

xii. There was no significant interaction among attitude towards chemistry, gender and score levels of students exposed to ASEI-PDSI instructional strategy;

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

The main objective of this study was to examine whether ASEI-PDSI instructional strategy would enhance students' achievement, improve their self-efficacy and develop positive attitude towards chemistry. Thus, this chapter presents discussion of findings, the conclusions, recommendations and suggestion for further studies.

Discussion of Findings

This study found out that a significant difference existed in the achievement of students exposed to ASEI-PDSI instructional strategy (experimental) and those not exposed to the ASEI-PDSI instructional strategy (control), which was in favour of the experimental group. This implies that the experimental group exposed to ASEI-PDSI instructional strategy performed significantly better in chemistry than their control group counterparts. The results showing improved achievement could be attributed to the fact ASEI-PDSI instructional strategy allows the students to construct their own knowledge based on their understanding rather than becoming passive listeners to be filled with information.

Also, the students in experimental group worked cooperatively with one another, exchanged ideas while they interact with the materials provided, and they were able to relate chemistry concepts to their day-to day activities through the use of locally available materials. Hence, this accounted for their better achievement. This finding agrees with the findings of Adamu (2017); Mwelese and Awoto (2014) as they also attested to the efficacy of ASEI-PDSI instructional strategy. Thus, the ASEI-PDSI instructional strategy is an effective instructional strategy for improving students' achievement in chemistry.

A finding also revealed that a significant difference existed in the self-efficacy of students exposed to ASEI-PDSI instructional strategy (experimental) and those not exposed to the ASEI-PDSI instructional strategy (control), in the positive direction of the experimental group. This implies that the experimental group exposed to ASEI-PDSI instructional strategy possessed high self-efficacy in chemistry than their control group counterparts. This could be explained by the increased knowledge that resulted from sharing of resources and ideas, each individual having a specific task assigned and interdependence on one another. This finding agrees statistically with the findings of Fitriyana, Niyarsi and Sugiyarto (2018); Rachmah (2017) that better mode of instruction could enhance students' self-efficacy.

Conversely, the finding is not consistent with that of Mari and Gumel (2015); Abdelraheem (2014). Although, these researchers also believed that when students are engaged in activities, self-efficacy are enhanced which could result to better achievement. Therefore, ASEI-PDSI instructional strategy is an effective strategy that may be used to enhance self-efficacy in chemistry.

On the other hand, the outcome of this study revealed no significant difference in attitude of students exposed to ASEI-PDSI instructional strategy and those not exposed. This implies that the ASEI-PDSI instructional strategy did not bring about any significant change in attitude towards chemistry. Although, mean score for the experimental group was higher than that of the control. In this study, the benchmark for positive attitude was set to be 50 (62.5%), the two groups already met this benchmark before the treatment. That is, their attitude was already positive. Hence, this may account for the statistical insignificant after the treatment was administered.

This finding agrees statistically with the findings of Sengul and Katranci (2014); Bamidele, Adetunji, Awodele and Irinoye (2013) and however, disagrees with Protus, Martin, and Shikuku (2020); Almasaeid (2014); Mwelese and Atwoto (2014); and Achor (2013). Although, it appeals to common sense that better mode of instruction like the ASEI-PDSI instructional strategy should promote positive attitude in students but the outcome of this study indicated that this may not happen all the time. The differences observed could be as a result of influence of other students' variables unknown to the researcher.

Finding on influence of gender on achievement of students taught with ASEI-PDSI instructional strategy revealed a significant difference in the achievement of male and female students before they were exposed to the treatment. On the other hand, no significant difference was recorded in their achievement after the treatment. This implies that both male and female benefited equally when exposed to the treatment, that is, the female can achieve as well as male in chemistry. This could be because, during the treatment, the instructor made sure that all students were assigned specific roles and task without considering their gender. Hence, this may have accounted for the statistical insignificance in their achievement and perhaps, ASEI-PDSI instructional strategy could eradicate gender inequality in science.

This finding agrees with previous research findings of Adamu (2017); Ajayi and Ogbeba (2017); Olatoye, Aderogba, and Aanu (2011); Udousoro (2011) that there was no significant difference in the achievement of male and female students in chemistry. However, findings of Aniodoh and Egbo (2013); Cheung (2009) disagrees with the finding of this study which reported female students achieving more than their male counterparts. This according to them, is perhaps as a result of their active role during classroom instruction.

The finding on influence of gender on self-efficacy of students exposed to ASEI-PDSI instructional strategy suggested a significant difference in self-efficacy of male and female

students exposed to the treatment, which was in favour of the males. This implies that the male students possessed high self-efficacy than their female counterparts. The high self-efficacy of the male students could be as a result of the fact that, in most of the groups, the male assumed the leadership role, were always the first to carry out any activity that involve manipulation of materials and more favourably disposed to the activities.

This finding is coherent statistically with the findings of Ahmad (2012); Garcia (2010) that reported that male students possessed high self-efficacy in chemistry than their female counterparts. However, the findings of Sawari and Mansor (2013); Tenaw (2013) contrast the finding of this study. They reported no significant difference in self-efficacy of male and female students.

Finding on the influence of gender on attitude of students exposed to ASEI-PDSI instructional strategy revealed no significant difference in the attitude of male and female students exposed to the treatment. This implies that being a male or female doesn't influence their attitude towards chemistry. The reason could be adduced to the fact that both the males and females appreciated their active roles in the learning process, and as such, contributed to better understanding and the enhanced achievement.

The finding supports the earlier findings of Sofiani, Manlida, Fadhillah, and Sihita (2017); Ebuoh (2011) which reported no significant difference in male and female attitude towards chemistry. It however, contradicts the findings of Kenar *et al.* (2015); Oluwatelure (2015); Heng and Karpudewan (2014); Achor (2013) that reported significant difference in the attitude of male and female students in chemistry. The differences could because of their believe that male students are being highly engaged in attention seeking activities.

The outcome of this study on influence of score levels on achievement of students exposed to ASEI-PDSI instructional strategy revealed a significant difference between high

and low and no significant difference between low and medium; and medium and high. This implies that the treatment succeeded in moving the low scorers to medium and medium scorers to high. Also, the achievement of the high scorers was enhanced. Hence, the treatment benefited all students across the score levels. This was expected because all the students were enthusiastic during the class activities regardless of the score level they belong, each of them had specific role assigned to them and they reported their findings correctly. Also, students, especially low scorers are envisaged to do well in class activities that involve manipulation of objects. This finding is coherent with the findings of Catalano (2010); Mariano and Kirby (2009); Venkatakrishnan and William (2003) and refutes the finding of Adodo and Agbayewa (2011); and Kang (2006).

In the same vain, no significant difference in the self-efficacy and attitude of low, medium and high scorers exposed to ASEI-PDSI instruction. This suggested that score levels did not influence the students' self-efficacy and attitude when exposed to ASEI-PDSI instruction. That is, the self-efficacy and attitude of the students were congruent irrespective of the category they belong.

Similarly, a finding revealed no significant interaction effect among treatment, gender and score levels on students' achievement in chemistry. The implication of this, is that the gender and score levels did not have any influence on the achievement of students exposed to ASEI-PDSI instructional strategy. That is, their improved achievement was as a result of the treatment alone. This was because the ASEI-PDSI instructional strategy gives individual opportunities to explore, manipulate the available materials, and make deductions based on their experience, irrespective of their gender and score levels. This finding is congruent with findings of Ajayi and Ogbeba (2017); Mwelese and Awoto (2014); Olatoye, Aderogba, and Aanu (2011); and disagrees with the findings of Adebayo (2008); Bamiro (2015) that reported significant interaction among moderating variables and treatment.

A finding also suggested no significant interaction effect among treatment, gender, and score levels on students' perceived self-efficacy chemistry. This implies that the improved self-efficacy of the students that were exposed to ASEI-PDSI instruction was solely as a result of the treatment. That is, neither their gender no score levels had influence on the enhanced self-efficacy. This finding conforms with the findings of Olatoye, Aderogba, and Aanu (2011); Tuyuz (2010).

Conversely, a finding revealed that there was interaction among treatment, gender, score levels on students' attitude towards chemistry. However, this interaction was not statistically significant. This finding could be linked to the finding that reported no significant difference in the attitude of experimental and their control group counterparts. That is, interaction of gender and score levels might have contributed to the no difference observed. This implies that students' attitude towards chemistry might be influenced by their gender or score levels.

Conclusions

Available literature reviewed in this study established that achievement of students in chemistry certificate examinations is inconsistent and substandard. In an attempt to proffer solution to this under-achievement, this study examined whether ASEI-PDSI instructional strategy would improve students' achievement, enhance their self-efficacy and develop positive attitude towards chemistry. Based on the results and earlier discussion of findings, the following conclusions were made:

The use of ASEI-PDSI instructional strategy in teaching chemistry enhanced students' performance. This implies that if teachers endeavor to use ASEI-PDSI instructional strategy in teaching chemistry, students' enhanced achievement is assured. Also, there was improved self-efficacy and the attitude of the students towards chemistry when taught with the ASEI-

PDSI instructional strategy. It is also worthy to note that, this enhanced achievement, self-efficacy and attitude were solely as a result of the effect of the ASEI-PDSI instructional strategy. Hence, it could be concluded that ASEI-PDSI instructional strategy improved students' achievement, self-efficacy and attitude towards chemistry.

Similarly, the ASEI-PDSI instructional strategy succeeded in minimizing the gender stereotype among the students, as there was no significant difference in the achievement and attitude of male and female students exposed to ASEI-PDSI instructional strategy. Thus, ASEI-PDSI instructional strategy is gender friendly.

Score levels' influence was also curtailed by ASEI-PDSI instructional strategy. The ASEI-PDSI instructional strategy was able to bridge the gap between low and medium scorers; and medium and high scorers for the achievement test, and no difference recorded among the score levels in self-efficacy and attitude tests. This implies that all students benefited equally irrespective of their score levels. Hence, ASEI-PDSI instructional strategy is effective.

Recommendations

Based on the findings from this study, the following recommendations are considered pertinent:

i. In view of the fact that ASEI-PDSI instruction instructional strategy enhanced achievement, self-efficacy and attitude towards chemistry, chemistry teachers should adopt ASEI-PDSI as a mode of instruction.
ii. Because of the improved understanding of chemistry, as a result of treatment with ASEI-PDSI, the curriculum planners and textbook writers should infuse activities into

all concepts to be learnt, and emphasize the use of locally available materials as these are what ASEI is made of.

iii. Science teachers, especially teachers of chemistry should endeavor to relate chemistry concepts to the students' real life experiences, assign task to them, pose questions to foster critical thinking and do not condemn wrong answers. All these, are elements of ASEI which might be used to enhance self-efficacy; and develop positive attitudinal change towards chemistry.

iv. In view of the fact that gender stereotype was eliminated in ASEI-PDSI classroom, the government, ministries of education and other stakeholders should organize in-service training for teachers by adopting SMASE training guide on gender sensitivity among teachers in science classrooms.

v. Chemistry teachers should also vary their classroom interaction patterns allow for individual thinking time when questions are asked, take care of introvert and extrovert students. This will allow all students to participate actively during instruction regardless of the score levels they belong.

Suggestions for Further Studies

Beside affirming the efficacy of ASEI-PDSI instructional strategy, the results of this study also confirmed that students' gender and score levels did not mediate with the effectiveness of ASEI-PDSI instructional strategy. As such, the following suggestions are considered relevant for future research studies:

i. Future studies can consider effects of ASEI-PDSI instructional strategy on other difficult concepts in chemistry

ii. Effects of ASEI-PDSI instructional strategy may be carried on other science subjects such as physics, biology and mathematics

iii. Other moderating variables such as school type, learning style, cognitive style could be incorporated into the study

iv. Effects of ASEI-PDSI instructional strategy on other variables such as students' views, self-concepts, interest and so on could be considered.

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APPENDIX I

ACIDS, BASES & SALTS ACHIEVEMENT TEST (ABSAT)

Instruction: ATTEMPT ALL QUESTIONS IN SECTIONs A and B

Duration: 1hour

Student's code:

Gender:

School code:

SECTION A

1.Which of the following statements is true about acids and bases?

(a)acids and bases don't react with each other

(b) acids mixed with bases to neutralize each other

(c) acids mixed with bases make stronger bases

(d) acids mixed with bases make stronger acids

2. Which of these is an example of deliquescent substance?

(a) quicklime

(b)Copper oxide

(c)sodium hydroxide

(d)sodium trioxocarbonate (iv)

3. Neutral solutions have a pH of:

(a) 0

(b) 1

(c) 7

(d) 14

4. Which of the following substances will not dissociate in water completely?

(a) CH_3COOH

(b) HCl

(c) HNO_3

(d) H_2SO_4

5. A chemical species having one ionizable hydrogen ion is:

(a) monoprotic

(b) diprotic

(c) tripotic

(d) polyprotic

6. Vinegar, fruit juice, and cola are examples of:

(a) strong acids

(b) weak acids

(c) strong bases

(d) weak bases

7. Which of the following is an acid salt?

(a) $NaHSO_4$

(b) Na_2SO_4

(c) CH_3COOH

(d) Na_2S

8. The neutralization reaction between sodium hydroxide solution and nitrogen (iv) oxide produces water and ----------

(a) $NaNO_2$ and $NaNO_3$

(b) $NaNO_3$ and HNO_3

(c) $NaNO_3$

(d) $NaNO_2$

9.---------- is a phenomenon whereby certain substances absorb moisture on exposure to the atmosphere and dissolve in it.

(a) Efflorescence

(b) Hygroscopy

(c) Deliquescence

(d) Hydrolysis

10. Which of the following salts will dissolve in water to give a solution of pH7?

(a) NH_4Cl

(b) $FeCl_3$

(c) CH3COOK

(d) KCl

11. Sodium hydroxide is added drop by drop to some hydrochloric acid in a beaker. Which of the following occurs in the beaker?

(a) the pH of the solution decreases

(b) the concentration of hydrogen ion increases

(c) the concentration of hydrogen ion remain constant

(d) the pH of the solution increases

12. Which of these acids is most likely to be dangerous?

(a) citric acid

(b) carbonic acid

(c) hydrochloric acid

(d) ascorbic acid

13. Universal indicator solution is usually green to begin with. What does this mean?

(a) it is acidic

(b) it is alkaline

(c) it is neutral

(d) it is amphoteric

14. What products are formed when a metallic trioxocarbonate iv reacts with an acid?

(a) a salt only

(b) a salt and water

(c) water and carbon (iv) oxide

(d) a salt, water and carbon (iv) oxide

15. Farmers use slaked lime to neutralize their soils. What sort of substance is slaked lime?

(a) base

(b) acid

(c) a sharp tasting drink

(d) salt

16. What phenomena is represented in the equation below?

$Na_2CO_3.10H_2O \rightarrow Na_2CO_3.H_2O + 9H_2O$. (a) efflorescence

(b) deliquescence

(c) hygroscopy

(d) hydrolysis

17. A solution with a pH of 4-6 is considered ----------

(a) strong acid

(b) weak acid

(c) weak base

(d) strong base

18. A base would best be described as ----------

(a) a proton acceptor

(b) an electron acceptor

(c) a proton donor

(d) an electron donor

19. If pOH of a solution is 6, what is the pH?

(a) 10

(b) 14

(c) 6

(d) 8

20. Na_2CO_3 ionizes in solution to give

(a) acidic solution

(b) basic solution

(c) neutral solution

(d) weak solution

SECTION B

21.Define the term hydrolysis of salt

22.Classify the following as acids, bases and salts

i. lemon

ii. $K_4Fe(CN)_6$

iii. HNO_3

iv. Quicklime

v. limestone

23. classify these salts as soluble and insoluble salts

i. potassium trioxocarbonate (iv)

ii. silver chloride

iii. ammonium tetraoxosulphate(vi)

iv. zinc trioxonitrate(v)

v. magnesium trioxocarbonate (iv)

24. How would you prove that sodium hydroxide is a base without using litmus paper to test?

---

25. Differentiate between strong acid and concentrated acid

---

26. What is pH of $(NH_4)_2SO_4$ salt in solution? Give reason for your answer

---

---

27. Complete the table below

Acid/base reaction	**Suitable indicator**
KOH Vs HCl	
H_2SO4 Vs $Ca(OH)_2$	
H_3PO4 Vs NaOH	
CH_3COOH Vs NH_3	

APPENDIX II

ATTITUDE TOWARDS CHEMISTRY SCALE (ATCS)

Student's code:

Gender:

School code:

Instruction: here are number of statements that may or may not describe your beliefs about learning chemistry. You are enjoined to rate each statement by ticking one of the following choices that best expresses your feeling about the statement.

1. Strongly Disagree (SD)
2. Disagree (D)
3. Agree (A)
4. Strongly Agree (SA)

Note: this is an inventory about how you learn and **not an examination**. Please be sincere as much as possible as there are no correct or incorrect response.

S/N	STATEMENTS	SD	D	A	SA
1.	I like chemistry more than any other school subject				
2	I know and understand chemistry				
3.	Chemistry lessons are interesting				
4.	Experiment in chemistry class is easy to carryout				
5	If I have option for chemistry, I will opt out of the lesson				
6.	Doing chemistry experiments in school is fun				
7	I can learn chemistry effectively with little or without my chemistry teachers' help				
8.	Chemistry is useful for solving everyday problem				
9.	Chemistry is abstract in nature than any other science subject				
10.	It is not important for me to be successful in chemistry				
11	If chemistry is not a compulsory subject for science students, I will not sit for it in certificate examination				
12.	It is bothersome for me to try solving chemistry problem				
13	Learning chemistry is not easy for me				
14	I only study chemistry because it is compulsory for science students in the secondary school certificate				
15	I am always nervous while doing chemistry experiment				
16	Only brilliant students should study chemistry				

17	I am willing to spend more time reading chemistry textbooks
18	I will like to teach chemistry when I leave school
19	Chemistry cannot solve all our problems
20	People must understand chemistry because it affects their lives

APPENDIX III

CHEMISTRY SELF-EFFICACY SCALE (CSES)

Student's code:

Gender:

School code:

Instruction: here are number of statements that seek to measure your confidence about chemistry. You are enjoined to rate each statement by ticking one of the following choices that best expresses your feeling about the statements

1. Strongly Disagree (SD)
2. Disagree (D)
3. Agree (A)
4. Strongly Agree (SA)

Note: this is an inventory about how you learn and **not an examination**. Please be sincere as much as possible as there are no correct or incorrect response.

S/N	Statements	SD	D	A	SA
1	I can do well in acids, bases and salt exam				
2	I can do well than other students in acids, bases, and salts exam				
3	I can confidently work with acids				
4	I can easily differentiate between strong and concentrated acids				
5	I am so sure that pH is relevant to digestion of food in the body				
6	I can identify acids that form normal salts only				
7	I can conveniently explain how an acid-base indicator works				
8	Constructing laboratory apparatus with local materials is easy for me				
9	I understand the rules of solubility of salts in water without any confusion				
10	Classifying chemical substances into deliquescent, efflorescent and hygroscopic is very easy for me				

APPENDIX IV

DISSEMINATION OF MAJOR FINDINGS

The findings of this study would be publicized as follows:

Journal Publications: The results obtained would be published in reputable journals of high academic standard.

Workshops: The researcher would also organize workshops on the meaning and concept of ASEI-PDSI instruction and how it can be integrated into teaching and learning of chemistry.

Seminars: Seminars would be organized by the researcher to sensitize senior school chemistry teachers across the state on the importance and the need to teach chemistry concepts with more student-centered and activity-oriented instructional strategy like the ASEI-PDSI instruction.

Print Media: Articles would be published in the media on how ASEI-PDSI instruction can enhance teaching and learning of chemistry concepts, challenges that may be encountered during classroom actualization of ASEI-PDSI instruction, and their way forward would be identified.

APPENDIX V

LESSON TIME TABLE AND MODULES FOR INSTRUCTION

PERIOD	ACTIVITIES
ONE	Acids: meaning, classes, properties, preparation and uses
TWO	Bases and Alkalis
THREE	Relative acidity and alkalinity (pH scale)
FOUR	Salts
FIVE	Soluble and insoluble salts
SIX	Efflorescent, deliquescent and hygroscopic substances

LESSON MODULE I: ACIDS

LESSON OBJECTIVES: By the end of the lesson, the students should be able to:

- Define acid
- Give examples of organic and mineral acids
- Differentiate between strong, weak, concentrated, and dilute acids
- Describe the properties of acids
- Mention the uses of acids

LEARNING MATERIALS: hydrochloric acid, lemon, vinegar, methylorange, oranges, milk etc.

PRESENTATION:

Acids are usually recognized by their sour taste i.e the taste of unripe fruit and their ability to turn blue litmus paper to red. There are two classes of acids: organic and mineral/inorganic acids. The formal occur as natural products in plant or animal while the latter can be prepared from mineral elements or inorganic matter.

Examples of organic acids:

Organic acids	Source
Ethanoic acid	Vinegar
Lactic acid	Milk
Citric acid	Lime, lemon
Amino acids	Proteins
Ascorbic acid	Oranges
Fatty acids	Fats and oils
Tartaric acid	Grapes

Examples of mineral acids:

Mineral acid	Formula	Constituents
Hydrochloric acid	HCl	Hydrogen, chlorine
Tetraoxosulphate VI acid	H_2SO_4	Hydrogen, Sulphur, oxygen
Trioxonitrate V acid	HNO_3	Hydrogen, nitrogen, oxygen

Acids in Solution

When acids are dissolved in water, they ionize to produce positive hygrogen ion called proton (H^+) or hydroxonium ion (H_3O^+) and negative ion e.g

$HCl_{(aq)} \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$ or

$HCl_{(aq)} + H_2O_{(l)} \longrightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$

Hence, an acid is any substance which when dissolve in water will produce hydrogen or hydroxonium ion as the only positive ion. Thus, an acid has at least one ionizable hydrogen atom in its molecule. Strong acids ionize completely in water to give hydrogen ions and anions while weak acids are only partially ionized in water. eg

$HNO_{3(aq)} \longrightarrow H^+_{(aq)} + NO_3^-{}_{(aq)}$

$H_3PO_{4(aq)} \rightleftharpoons 3H^+_{(aq)} + PO_4^{3-}{}_{(aq)}$

If a large amount of water is added to a small amount of acid, the resulting acid solution is dilute. If only little water is added to relatively large amount of acid, the solution will be concentrated.

Basicity of an acid

The basicity of an acid is the number of replaceable hydrogen ions in one molecule of the acid

Physical properties of acids

- Dilute acids have a sour taste
- Acids turn blue litmus red
- Concentrated form of strong acids are corrosive

Chemical properties of acids

- Reaction with metals: acids react with metals like zinc, iron to liberate hydrogen gas
  $2HCl_{(aq)} + Zn_{(s)} \longrightarrow ZnCl_{2(aq)} + H_{2(g)}$
- Reaction with bases: acids react with insoluble bases and alkalis to form salts and water as the only product. Such a reaction is known as neutralization
  $H_2SO_{4(aq)} + 2KOH_{(aq)} \longrightarrow K_2SO_{4(aq)} + 2H_2O_{(l)}$
- Reactions with trioxocarbonates(vi): acids react with the trioxocarbonates(iv) to liberate carbon(iv) oxide

$$2HCl_{(aq)} + Na_2CO_{3(aq)} \longrightarrow 2NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

Preparation of acids

- Dissolving an acid anhydride in water: acid anhydride are non-metallic oxides which dissolve in water to produce various acids. Carbon(iv) oxide dissolves in water to form hydrogen trioxocarbonate (iv) acid; Sulphur (iv) oxide dissolves to form trioxosulphateIV acid; and Sulphur (iv) oxide dissolves to form tetraoxosulphate (iv) acid eg $SO_{2(g)} + H_2O_{(l)} \longrightarrow H_2SO_{3(aq)}$
- Combination of constituent elements: burning of hydrogen in the presence of activated charcoal as catalyst yields hydrogen chloride gas which dissolves in water to give hydrochloric acids

  $$H_{2(g)} + Cl_{2(g)} \xrightarrow{\text{activated charcoal}} 2HCl_{(g)}$$

- Using a strong acid to displace a weak acid or a volatile acid from its salt

  $$2NaNO_{3(aq)} + H_2SO_{4\ (aq)} \longrightarrow K_2SO_{4(aq)} + 2HNO_{3\ (g)}$$

Uses of acids

- Acids such as tetraoxosulphate(vi) acid are used in the manufacture of fertilizers, detergents, dyes, drugs, and plastics
- Acids such as trioxonitrate(v) acid are used in the manufacture of fertilizers and explosives. Ethanoic acid is used for preserving foods
- Acids such as fatty acids are used for making soap
- Acids such as hydrochloric acid is used for cleaning metals or removing rust

MODULE II: BASES & ALKALIS

LESSON OBJECTIVES: By the end of the lesson, the students should be able to:

- Define bases and alkalis
- Define neutralization reaction
- Describe the properties of acids
- Mention the uses of acids

LEARNING MATERIALS: sodium hydroxide solution, methylorange.

PRESENTATION:

A base is a compound which will neutralize acids and turn red litmus paper blue. Bases are usually metallic oxides or metallic hydroxides. Common examples of basic oxides are sodium oxide, Na_2O, potassium oxide, K_2O, magnesium oxide, MgO etc. they are formed when these metals burn in air or oxygen

$$4Na_{(s)} + O_{2(g)} \longrightarrow 2Na_2O_{(s)}$$

Most metallic oxides are insoluble in water. Some, however, dissolve in water to form hydroxides

$$Na_2O_{(s)} + H_2O_{(l)} \longrightarrow 2NaOH_{(aq)}$$

A soluble hydroxide is known as alkali. Thus, an alkali is a basic hydroxide which is soluble in water.

Neutralization reaction

Neutralization is a process in which an acid reacts completely with an appropriate amount of an alkali or any other base to produce salts and water only. During the reaction, the hydrogen ion, from acid is neutralized by the hydroxide ion from the alkalis to form water molecule

$$H^+_{(aq)} + OH^-_{(aq)} \rightleftharpoons H_2O_{(l)}$$

Physical Properties of Alkalis

- Alkalis have bitter taste
- Alkalis are soapy to touch
- Alkalis turn red litmus blue
- Concentrated form of the two caustic alkalis are corrosive

Chemical Properties of Alkalis

- Reaction with acids: all bases react with acids to form salt and water only

  $$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$

  $$MgO_{(s)} + 2HNO_{3(aq)} \longrightarrow Mg(NO_3)_{2(aq)} + H_2O_{(l)}$$
- Reaction with ammonium salts: alkalis react with ammonium salt in the presence of heat to generate ammonia gas

  $$Ca(OH)_{2(aq)} + 2NH_4Cl_{(aq)} \longrightarrow CaCl_{2(aq)} + 2H_2O_{(l)} + 2NH_{3(g)}$$

Uses of Alkalis

alkalis are important substances used in industries concerned with the manufacture of:

- Glass
- Soap
- Paper
- Rayon
- Some alkalis are used to soften water

MODULE III: RELATIVE ACIDITY AND ALKALINITY (pH SCALE)

LESSON OBJECTIVES: By the end of the lesson, the students should be able to:

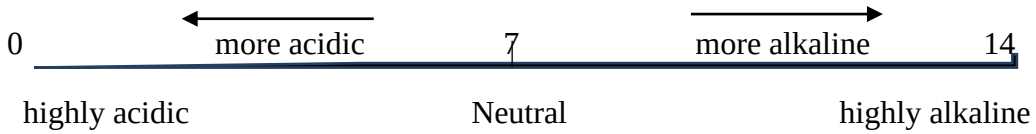
- Explain how an acid-base indicator works
- Use pH as a scale and discuss the importance of the pH value

LEARNING MATERIALS: methylorange, phenolphthalien and litmus paper

PRESENTATION:

pH scale

The acidity and alkalinity of substances are measured using a scale numbers from 0-14, called the pH scale. Solution of pH value of 7 is neutral i.e neither acidic nor basic. A solution with a pH value less than 7 is acidic while one with a value more than 7 is alkaline. Acidity increases with decreasing pH values while alkalinity increases with increasing pH values



highly acidic Neutral highly alkaline

Importance of pH

- In our body, acidic medium is needed for digestion of food in the stomach while basic medium is needed in the small intestine.
- Soil has pH values varying from 4-9
- The pH of normal human blood is 7.4
- pH values are also important in pharmacy, medicine, water purification, sewage treatment and several other industrial processes.

Acid-base indicators

These are weak organic acids or bases which change colour according to the pH of the medium. A universal indicator is a mixture of several indicators and changes colour gradually from red through green to violet over a wide pH range. Each indicator has its own specific pH range over which it changes colour.

Colour changes of some indicators

Indicator	**Colour in acid solution**	**Colour in neutral solution**	**Colour in alkaline solution**	**pH range for colour change**
Methylorange	Red	Orange	Yellow	3-5
Litmus	Red	Purple	Blue	5-8
Phenolphthalein	Colourless	Pale pink	Pink	8-10

M**easuring pH of solution**

pH of a solution may be measured by universal indicators or pH meters. A universal indicator is made up of various indicators which work at different pH ranges. This method of measuring pH is not very accurate. The pH of a solution can be measured accurately by using a pH meter.

Acid-base reaction	Change of pH at end-point	Suitable indicator
Strong acid Vs strong alkali	3-11	Any indicator
Strong acid Vs weak alkali	3-6	Methylorange or litmus
Weak acid Vs strong alkali	8-11	Phenolphthalein
weak acid Vs weak alkali	6.5-7.5	No suitable indicator

MODULE IV: SALTS

LESSON OBJECTIVES: By the end of the lesson, the students should be able to:

- define salts
- mention the type of salts
- state the uses of salts
- describe the preparation of salts

LEARNING MATERIALS: methylorange, litmus paper, salts samples

PRESENTATION

A salt is the compound formed when all or part of the ionizable hydrogen of an acid is replaced by metallic or ammonium ion

Types of salts

Normal salts: these are formed when all the replaceable hydrogen ions in the aids have been completely replaced by metallic ions

- $NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$
- $H_2SO_{4(aq)} + 2KOH_{(aq)} \longrightarrow K_2SO_{4(aq)} + 2H_2O_{(l)}$

Acid salts: these are formed when the replaceable hydrogen ions in acid are only partially replaced by a metal and are produced only by acids containing more than one replaceable hydrogen ions. Acids salts still contain replaceable hydrogen ions and hence, have acidic properties

- $H_2SO_{4(aq)} + KOH_{(aq)} \longrightarrow KHSO_{4(aq)} + 2H_2O_{(l)}$

Basic salts: these contain hydroxide ion, OH^-. They occur when there is insufficient supply of acids which is needed for complete neutralization of the base eg Zn(OH)Cl, Mg(OH)Cl etc.

Double salts: these are salts which ionize to produce three different type of ion in solution where two are positively charged while the other is negatively charged eg $CaMg(CO_3)_2$, $KAl(SO_4)_2$

Complex salt: these salts contain complex ions i.e ions consisting of charged group of atoms eg $K_4Fe(CN)_6$

Uses of salts

- salts are used in the manufacture of many industrial, agricultural and consumer substances like chlorine gas, fertilizers, and laxatives.
- They are used as food preservatives, drying agents and antifreeze

Preparation of Salts

There are several method of preparing salts. The method chosen for preparing a particular salt depends on: its solubility in water; and its stability to heat. Salts may therefore, be classified as soluble and insoluble salts

Soluble salts	Insoluble salts
All salts of potassium, sodium and ammonium	-
All trioxonitrates V	-
All chlorides except	Lead, silver and mercury chloride
All tetraxosulphates VI except	Lead, barium, calcium tetraoxosulphates VI is slightly soluble
Trioxocarbonates IV of potassium, sodium and ammonium	All other trioxocarbonates

Preparation of Soluble Salts

Soluble salts may be prepared by various methods. These salts in aqeous solutions and should be recovered from these solutions by evaporation or crystallization.

- Reaction between acid and metal

$$2HCl_{(aq)} + Zn_{(s)} \longrightarrow ZnCl_{2(aq)} + H_{2(g)}$$

- Reaction between acid and alkali

$$H_2SO_{4(aq)} + 2KOH_{(aq)} \longrightarrow K_2SO_{4(aq)} + 2H_2O_{(l)}$$

- Reaction between acid and insoluble base

$$HNO_{3(aq)} + CuO_{(s)} \longrightarrow CuSO_{4(aq)} + H_2O_{(l)}$$

- Reaction between dilute acid and trioxocarbonate IV

$$2HCl_{(aq)} + Na_2CO_{3(aq)} \longrightarrow 2NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g}$$

Preparation of Insoluble Salts

Salts which are insoluble in water can be prepared in the laboratory by the following method:

- Double decomposition

$AgNO_{3(aq)} + NaCl_{(aq)} \longrightarrow AgCl_{(aq)} + NaNO_{3(aq)}$

- Combination of constituent elements

$2Fe_{(s)} + 3Cl_{2(g)} \longrightarrow 2FeCl_{3(s)}$

Hydrolysis of salts

Hydrolysis means reaction with water. Salts are strong electrolytes and when dissolved in water, they are expected to form solutions which have no effect on litmus paper. This is not the case for some salts as they show pH greater than 7 (alkaline solutions) or pH less than 7 (acidic solutions). This has been found to be true for salts derived from weak acids or weak bases

Salt	Type of acid and base from which they are formed	Acid-base nature of the aqeous solution
NaCl	Strong acid and strong base	Neutral, pH = 7
Na_2CO_3	Weak acid and strong base	Alkaline, pH > 7
$FeCl_3$	Strong acid and weak base	Acidic, pH < 7
CH_3COONH_4	Weak acid and weak base	Neutral, pH = 7
$Al_2(SO_4)_3$	Strong acid and weak base	Acidic, pH < 7
NH_4NO_3	Strong acid and weak base	Acidic, pH < 7

MODULE V: EFFLORESCENT, DELIQUESCENT & HYGROSCOPIC SUBSTANCES

LESSON OBJECTIVES: By the end of the lesson, the students should be able to:

- define efflorescence, deliquescence and hygroscopy
- give examples of substances that exhibit these phenomena

LEARNING MATERIALS: sodium hydroxide pellets, washing soda crystals, quicklime and concentrated tetraoxosulphateVI acid

PRESENTATION

When certain compounds are exposed are to air, they either lose water of crystallization or they absorb moisture from their surroundings.

Efflorescence

This is the process whereby some crystalline salts lose part or all of their water of crystallization when they are exposed to the atmosphere to form a lower hydrate or anhydrous salt. The substances that undergo this phenomenon are efflorescent substances.

$$Na_2CO_3.10H_2O_{(s)} \longrightarrow Na_2CO_3.H_2O_{(s)} + 9H_2O_{(g)}$$

Deliquescence

This is the process whereby some compounds tend to absorb large amount of water on exposure to the atmosphere so that they eventually turn to solutions. The substances that undergo this phenomenon are known as deliquescent substances. Examples are: sodium hydroxide, iron III chloride, potassium hydroxide. Magnesium chloride etc

Hygroscopy

Hygroscopic substances also absorb moisture on exposure to the atmosphere. If they are solids, they will not form solutions but merely become sticky or moist. A hygroscopic liquid like concentrated tetraoxosulphate VI acid will absorb water from the air, usually diluting itself up to about three times its original volume. Other examples are: sodium trioxonitrate V, copper II oxide, quicklime. Hygroscopic substances are commonly employed as drying agents in the laboratory.

APPENDIX VI

ASEI LESSON PLAN SAMPLE

Class: SSI

Subject: Chemistry

Theme: Chemistry and Environment

Topic: Acids, Bases and Salts

Sub-topic: Acids

Duration: 40 minutes

Reference Material: Ababio, O. Y. (2013). New school chemistry for senior secondary schools (4th ed.). Onitsha: African First Publisher

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

- Define acids
- Mention the classes of acids
- Identify strong, weak, concentrated and dilute acids
- Describe the properties of acids

Rationale: Acids are commonly used at home but their uses are hardly linked to teaching and learning. Most fruits and common food we eat contain acids. However, only few people are aware of this fact. Hence, the need to teach this concept becomes imperative. Also, the students will appreciate the concept of acids when its importance is connected to our daily activities such as digestion of food, food processing and preservation, soap production etc.

Learning Materials : Tomatoes, unripe orange red & blue litmus, transparent cups, zobo extract, hydrochloric acid, ethanoic acid, garden egg, battery liquid.

Previous Knowledge: The students had tasted ripe and unripe fruits before now and are able to identify their various tastes

Pre-requisite Knowledge: The students have been taught symbols, formulae and equations

Lesson Development

Stage	Teacher's Support	Students' Activities	Learning Point
Introduction (6minutes) Full class session	The teacher provides two unknown liquids A& B and instructs the students to insert blue and red litmus paper in each solution. The teacher then asks if there is any difference between the two	the students insert the litmus in the two liquids solutions and note their observations liquid A turns blue litmus red blue litmus doesn't have effect on B red litmus doesn't have	Arousing students' interest and curiosity on the concepts of acids Introducing the concepts of acids

	liquids The teacher leads the students to the concept of acid by clarifying that liquid A is an acid because it turns blue litmus red and it is the only substance that will ionize in solution to produce hydrogen ion as the only positive ion	effect on liquid A & B. The students note down the meaning of acid	Bridging activity to the meaning of acids
Step I (6minutes) Group activities	The teacher assigns the students to groups and tells them to select their group leaders and secretary The teacher asks the students to carry out activity II as provided in the activity sheet The teacher clarifies that the natural substances as classified by the students are organic acids while the synthetic substances are inorganic or mineral acids	The students select their leaders and secretaries Learners carryout the activities as instructed and note the following: Orange: natural Tomatoes: natural Garden egg: natural Battery liquid: synthetic HCl: synthetic H_2CO_3: synthetic Oil: natural The students note down the points	Encouraging collaboration and assigning sense of responsibilities Identifying organic and inorganic acids Classes of acids distinguished
Step II (10minutes) Group activities	The teacher presents the following equations $HNO_{3(aq)} \rightarrow H^+ + NO_3^-$ $H_3PO_{4(aq)} \rightleftharpoons 3H^+ + PO_4^{3-}$ and asks if there is any difference between them The teacher asks the students to carry out activity III as provided on the activity sheet The teacher harmonizes that: Equation(i) represents strong acid that ionizes completely in solution $\rightarrow$	The students look at the equations and note that equation (i) proceeds in only one direction while equation (ii) proceeds in both directions The students carryout the activities as instructed and note the following: The students note down the points: solution C removed the rust on the coin immediately solution D also remove the rust but it took a while.	Identifying strong, weak, concentrated, and dilute acids Linking activities to concepts: strong, weak, concentrated and dilute acids clarified

	Equation (ii) represents a weak acid that partially ionizes in solution ⇌ Solution C is concentrated acid Solution D is dilute acid		
Step III (10miutes) Group activities	The teacher asks the students to carry out activity IV as contained in the activity sheet	The students carry out the activity as instructed and note the following: Taste of unripe orange: sour Testing tomato juice with litmus: blue litmus changes to red Testing lemon juice with improvised litmus: changes to pink Rubbing small quantity of garden egg juice between finger tips: become slippery and sometimes gummy	Identifying the properties of acids
Evaluation (4minutes) Full class session	The teacher asks the following questions to evaluate the lesson What is an acid? Mention the classes of acid Differentiate between strong and weak acid Mention 3 properties of acids	The expected responses are: Acids are substances that produce hydrogen ion as the only positive ion when dissolved in water Organic and inorganic acid Strong acids ionize completely in solution while weak acids partially ionize in solution Acids have sour taste Acids turn blue litmus red Acids are slippery to touch	Confirming students' understanding of the concepts of acids
Conclusion (4minutes) Full class session	The teacher summarizes the lesson based on students' responses to the questions above. To enhance deeper understanding, the teacher also clarifies areas of misconceptions and confusions.	The students asks questions on the area they find difficult	Deepening understanding of acids

ASSIGNMENT: describe the chemical properties of acid

APPENDIX VII

ASEI INTERACTION PLAN SAMPLE

QUESTIONS/STATEMENTS	EXPECTED ANSWER	QUESTIONING TECHNIQUE
What is the difference between liquids A & B using litmus?	liquid A turns blue litmus red	The teacher points to students who raise their hands
You are provided with the following substances: Orange; tomatoes; garden egg battery liquid; HCl; H_2CO_3; oil; milk, vinegar; soya beans. Classify them as natural and synthetic substances.	Orange: natural Tomatoes: natural Garden egg: natural Battery liquid: synthetic HCl: synthetic H_2CO_3: synthetic Oil: natural	Points to students randomly in groups
What is the difference between equation I & II?	Equation I proceeds in only one direction while equation II proceeds in both directions	The teacher chooses who answer the question
Liquid X is a battery liquid. Get two transparent containers and label them C and D. Add 5mls and 50mls of water to C and D respectively. Divide the liquid X into two equal parts. Pour each half into C and D and stirr (note: do not pour water in liquid X) Immerse the dirty coin in both solutions simultaneously Note your observations What made solution C to remove the rust faster?	solution C removed the rust on the coin immediately solution D also remove the rust but it took a while Because solution C contains little amount of water Acids are substances that produce hydrogen ion as the only positive ion when dissolved in water Organic and inorganic acid Strong acids ionize completely in solution while weak acids partially ionize in solution	Points to students randomly in groups Points to student who raises hand
What is an acid? Mention the classes of acid Differentiate between strong and weak acid Mention 3 properties of acids	Acids have sour taste Acids turn blue litmus red Acids are slippery to touch	Pointing to two or more pupils who raise their hands one after the other

APPENDIX VIII

ASEI CHALKBOARD PLAN SAMPLE

Date:
Subject: Chemistry

Topic: Acids, Bases, and Salts
Sub-topic: Acids

Objectives: define acids
Mention the classes of acids
Mention the properties of acids

Introduction

Activity I

Test liquids A & B with red and blue litmus. What do you observe?

Acids

Activity II
Orange: natural; Tomatoes: natural; Garden egg: natural; Battery liquid: synthetic; HCl: synthetic; H_2CO_3: synthetic; Oil: natural

Activity III
Equation(i) represents strong acid that ionizes completely in solution
Equation (ii) represents a weak acid that partially ionizes in solution
Solution C is concentrated acid
Solution D is dilute acid

Activity IV
Taste of unripe orange: sour; Testing tomato juice with litmus: blue litmus changes to red; Testing lemon juice with improvised litmus: changes to pink; Rubbing small quantity of garden egg juice between finger tips: become slippery and sometimes gummy

Summary

Acids are substances that produce hydrogen ion as the only positive ion when dissolved in water
Acids are classified as organic and inorganic acid
Strong acids ionize completely in solution while weak acids partially ionize in solution
Properties of acids
Acids have sour taste
Acids turn blue litmus red
Acids are slippery to touch

Assignment

State 3 chemical properties of acids

APPENDIX IX

ASEI ACTIVITY SHEET SAMPLE

ACTIVITY I

You are provided with two clear liquids A & B. Insert damp blue and red litmus on the liquids and note your observations

Liquid	With blue litmus	With red litmus
A		
B		

ACTIVITY II

You are provided with the following substances: Orange; tomatoes; garden egg, battery liquid; HCl; H_2CO_3; oil; milk, vinegar; soya beans. Classify them as natural and synthetic substances

Natural	Synthetic

ACTIVITY III

Liquid X is a battery liquid.

Get two transparent containers and label them C and D.

Add 5mls and 50mls of water to C and D respectively.

Divide the liquid X into two equal parts.

Pour each half into C and D and stirr (**note: do not pour water in liquid X)**

Immerse the dirty coin in both solutions simultaneously

Note your observations

Activity	Observations
Solution C + dirty coin	
Solution D + dirty coin	

ACTIVITY IV

You are provided with the following substances: lemon, unripe orange, unripe pineapple, tomatoes, cattle milk, garden egg, blue and red litmus papers, transparent plastic containers, knife

ACTIVITY IV a: TASTING SAMPLES

(DO NOT TASTE UNLESS YOU ARE TOLD TO DO SO)

Cut each of the fruits provided into two parts

Squeeze the juice of each fruit into separate containers

Taste each sample of the fruits

What do you think is responsible for the taste?

Activity	Taste	Conclusion
Tasting lemon juice		
Tasting unripe orange juice		
Tasting tomatoes juice		
Tasting unripe pineapple juice		
Tasting garden egg juice		
Tasting lime juice		

ACTIVITY IV b: TESTING WITH LITMUS

Note: each solution should be tested with separate litmus

To one portion of the juice in activity IVa, dip blue litmus paper into it. What did you observe? What do you think is responsible for your observation above?

To the second container, dip red litmus paper and record your observation. What do you think is responsible for your observation?

To the juice in the third container, add few drops of the improvised litmus (zobo extract) and record your observation. What do you think is responsible for your observations?

Activity	With blue litmus	With red litmus	With improvised litmus	Remark
Testing lime juice				
Testing unripe orange				
Testing tomatoes juice				
Testing garden egg juice				
Testing lemon juice				

ACTIVITY IV c: FEELING THE SAMPLE SOLUTION WITH FINGER TIPS

To another portion of garden egg juice, rub small quantity between your fingertips. What do you feel? Record your observation

Activity	Observation	Inference
Rub small quantity of the juice between your fingertips. What do you observe?		

APPENDIX X

ACIDS, BASES & SALTS ACHIEVEMENT TEST (ABSAT) MARKING GUIDE
SECTION A

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

SECTION B

21. Hydrolysis of salts means reaction of salts in water.

22 .i. lemon - acid

ii. $K_4Fe(CN)_6$ - salt

iii. HNO_3 - acid

iv. Quicklime -base

v. limestone -salt

23 i. potassium trioxocarbonate iv -soluble salt

ii. silver chloride -insoluble salt

iii. ammonium tetraoxosulphate vi -soluble salt

iv. zinc trioxonitrate v -insoluble salt

v. magnesium trioxocarbonate iv - insoluble salt

24. Sodium hydroxide can be tested in the laboratory with the use of acid solution such as HCl. If the reaction produces salt and water only, then it is a base

25. A strong acid completely dissociate into its ions while concentrated acid is an acid that has not been diluted with water.

26. The pH of $(NH_4)_2SO_4$ solution will be less than 7 i.e $(NH_4)_2SO_4$ hydrolyzes in water to form acidic solution. This is because $(NH_4)_2SO_4$ is formed from strong acid and weak base (H_2SO_4 and NH_3).

27.

Acid/base reaction	**Suitable indicator**
KOH Vs HCl	Any indicator
H_2SO4 Vs $Ca(OH)_2$	Methyl orange
H_3PO4 Vs NaOH	Phenolphtalien
CH_3COOH Vs NH_3	No suitable indicator

APPENDIX XI

TABLE OF SPECIFICATION FOR ACIDS, BASES & SALTS ACHIEVEMENT TEST (ABSAT)

CONTENTS	REMEMBER	UNDERSTAND	APPLY	ANALYSE	CREATE	EVALUATE	TOTAL
Characteristics, preparations, and uses of acids, bases, salts	6	4	3	2	-	-	15
Relative acidity and alkalinity (the pH scale)	3	1	-	1	-	-	5
Deliquescent, efflorescent and hygroscopic substances	2	1	-	-	-	-	3
Solubility of salts in water	1	2	1		-	-	4
Total	12	8	4	3	-	-	27

APPENDIX XII

TEACHERS' TRAINING MANUAL

Introduction.

To enhance the quality of teaching/learning of mathematics and science, ASEI-PDSI approach is advocated. ASEI-PDSI stands for Activity, Student–Centered, Experiments and Improvisation and Plan, Do, See and Improve. The ASEI principle calls for paradigm shift from traditional practice of teacher-centered and knowledge-based teaching, through PDSI approach, to student-centered and activity based method.

What is ASEI?

ASEI is an acronym for Activity, Student–Centered, Experiment and Improvisation. It is an approach which aims at making teaching and learning more pupil-centered. It is therefore, a paradigm shift from 'banking style/chalk and talk' approach to 'activity based/pupil-centered approach'.

ASEI as an intervention strategy takes cognizance of how pupil learn. Pupils do not simply copy the science world rather they construct their own meanings of it. They must be provided with the opportunity to construct scientific knowledge through the interaction of their observations, prior knowledge and mental processes. The four principles, which form the basis for the ASEI pedagogical paradigm, are:-

i. Activity-oriented teaching: carefully selected activities to enhance pupil participation, interest, understanding and retention of knowledge.
ii. Student-focused learning: active pupils 'involvement in the teaching/learning process where the teacher guides and gives them opportunity to express opinion, explain ideas based on prior experiences and verify their opinions/ideas through suitably designed activities.
iii. Experiment/research based approach: scaled down, investigative experiments which are simpler, more relevant to specific lesson objectives and enable pupils to discover or reinforce new concept/ideas; rather those prescribed in the textbook.
iv. Improvisation: teacher innovativeness in the designing simple experiments/activities to enhance pupils' interest, participation, and learning; drawing from locally available resources and pupils' real life experiences.

What is PDSI?

PDSI is an acronym for Plan, Do, See and Improve. This is the means through which ASEI is achieved.

Plan

This is the actual preparation of lesson plan. The teacher identifies the lesson objectives, select materials and appropriate activities which should be well thought -out. The ASEI lesson through PDSI should contains the following features; introduction, content,

consolidation, and achievement of objectives, pupil's involvement and class management. The emphasis here, is on quality lesson planning that incorporate ASEI principle while at the same time not neglecting the fact that lesson planning should be unnecessarily demanding on the teacher in term of effort and time.

Do

This refers to the actual teaching or implementation of the planed lesson in the class room. The introduction of the lesson is expected to arouse the pupil's interest and curiosity. It should link the content of lesson to the pupil's previous knowledge or experiences. The lesson development should be sequenced to flow from known to unknown, concrete to abstract. The teacher should make use of pupil's knowledge and ideas; this enhances involvement as well as making them with the concepts been taught. The pupils should be assisted to bridge the activities to the concepts been taught. Findings from activities should be reported, discussed and harmonized. The teacher can use harmonized the results to develop the lesson further. Teacher should ensure greater teacher-pupil and pupil-pupil interactions during the lesson. At all times, the pupil should be the centre of the lesson.

See

This involves evaluating the lesson as it progresses by the teacher, pupils and a colleague for the sake of further improvement. As the lesson progresses, the teacher is expected to evaluate every step of the lesson with a view of improving in future.

Improve

From comments made or given and the teacher own evaluation, the teacher is expected to incorporate the changes in future similar lessons and hence make necessary improvements. Good aspects of the lesson be enhanced further, the unnecessary ones should be removed, the weak aspects should be strengthened and the lacking should be included.

HOW TO PLAN AND DO ASEI LESSONS

PLANNING

- Set the objectives of the lesson capturing what the learners can /cannot do
- Take into account learners' background such as learning difficulties, their needs/interests/misconceptions, growth of experimental skills and previous experience in relation to the topic
- Choose and prepare the appropriate and adequate teaching materials and activities based on lesson objectives
- Produce and/ or prepare improvised materials for practical works which help to achieve the objectives
- Select and combine learning style/ teaching methods that are appropriate to each step of the lesson for realizing the objectives of the lesson

- Plan for the black/white board use and how learners will copy the notes into their books

TEACHING

The most important points of the lesson should be explained by learners, not the teacher. That is, the teacher's role is to help the learners reach new concepts/ideas

Introducing the lesson

- Incorporate previous knowledge/skill/everyday experience of learners and link them to the new topic
- Clarify what you want the learners to learn
- Stimulate the learners enough to arouse their interest and curiosity
- Devise means of making learners ask questions and accept how they start

Developing the lesson

- Encourage learners to express their prior experiences and explain their ideas related to the content
- Encourage learners to give their own hypotheses/predictions and help to discuss how they differ from those held by others
- Encourage learners to give their own observations/ results in the activity and to discuss how they differ from others
- Encourage active participation in the main teaching steps

Questioning techniques

- Use language that can easily be understood by learners
- You should clarify the reason for asking a particular question
- Think of the order of question to the learners
- You should bear in mind the type of question to be asked

Choosing learners' responses to questions

- Make learners to explain other learners' ideas
- Guide learners on how to present ideas to others

Dealing with learners' ideas

- Catch learners' murmurs of learning
- Prepare how to deal with wrong answers from learners

- Relate learners' responses to lesson objectives
- Plan to deal with unexpected ideas from learners

Evaluating the lesson

- Supervise class/ group work
- Check accuracy, correctness, depth and appropriateness of the content through question and answer techniques
- Ensure that slow learners understand the content

Concluding the lesson

- Lesson should be concluded based on the set objectives
- Clarify what need to be summarized about the lesson
- Encourage learners to draw conclusions

APPENDIX XIII

UNIVERSITY OF ILORIN, ILORIN, NIGERIA

DEPARTMENT OF SCIENCE EDUCATION

INFORMED CONSENT FORM

Dear student,

I am pleased to inform you that you are selected to participate in a research. Your constant is hereby required to take part in the study. Detailed information about the research is provided below. Kindly endorse this consent form if you volunteer to participate in the study after reading about the research.

Purpose of the Research: the researcher seeks to examine the effects of ASEI-PDSI instruction on senior school students' achievement, self-efficacy beliefs and attitude towards chemistry in Ilorin Nigeria.

Procedure: student participants will be required to attend series of class lessons in chemistry. The lessons will take place during the regular chemistry class at the period allocated for chemistry on the class time table. ASEI-PDSI instructional strategies will be used to teach acids and bases for the period. Your chemistry teacher will be the one to teach you throughout the period of the experiment but the researcher will be coming to assist from time to time. You will be exposed to testing so as to monitor your progress and see how you could be assisted to improve in your areas of deficiency in chemistry. The test will be marked immediately and you will be given your script in order for you to be aware of your academic status in chemistry.

Confidentiality: all information provided by you will be treated with utmost confidentiality and used for the purpose of the research only.

Risk: All the lessons will take place during your regular classroom; hence no risk is envisaged throughout the research period.

Benefit: The likely benefits you may derive from research study include:

- Meaningful learning of chemistry through ASEI-PDSI instruction
- You stand to obtain a good grade in chemistry in the senior school certificate examinations conducted by WAEC and NECO and other public examination required for admission into university.

Right of volunteers (student participants): your participation in this research is voluntary: hence, if you decide not to take part of or stop your participation in the research at any time, you will not lose anything, if you have any question about research, you may contact the department of science education, university of Ilorin, Ilorin Nigeria or call researcher on cell phone number: 08034676566

Student Response Agreement: I hereby voluntarily consent to participate in the research. I know that I may refuse to participate or stop my participation in the research at any time. Also, I understand that if I have any question about the research or my right as a student participant, I may contact the Department of Science Education, University of Ilorin, Ilorin, Nigeria, or call the researcher on cell phone number: 08034676566.

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Student Participant	Signature	Date

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Parent/Guardian	Signature	Date

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Researcher	Signature	Date

UNIVERSITY OF ILORIN, ILORIN, NIGERIA

DEPARTMENT OF SCIENCE EDUCATION

INFORMED CONSENT FORM

Dear Teacher,

I am pleased to inform you that you are selected to participate in a research. Your constant is hereby required to take part in the study. Detailed information about the research is provided below. Kindly endorse this consent form if you volunteer to participate in the study after reading about the research.

Purpose of the Research: the researcher seeks to examine the effects of ASEI-PDSI instruction on senior school students' achievement, self-efficacy beliefs and attitude towards chemistry in Ilorin Nigeria.

Procedure: student participants will be required to attend series of class lessons in chemistry. The lessons will take place during the regular chemistry class at the period allocated for chemistry on the class time table. ASEI-PDSI instructional strategies will be used to teach acids and bases for the period. You will serve as research assistant to help teach your students throughout the periods but the researcher will be coming to assist from time to time. The students will be exposed to testing so as to monitor their progress and see how they could be assisted to improve in any areas of deficiency in chemistry. The test will be marked immediately and they will be given their scripts in order for them to be aware of their academic status in chemistry.

Confidentiality: all information provided by you will be treated with utmost confidentiality and used for the purpose of the research only.

Risk: All the lessons will take place during your regular classroom; hence no risk is envisaged throughout the research period.

Benefit: The likely benefits you may derive from research study include:

- Meaningful learning of chemistry through ASEI-PDSI instruction
- Immediate feedback from students on the impact of your teaching on their academic achievement
- You will be paid a token allowance of five thousand naira for the period of the study.

Right of volunteers (teacher participants): your participation in this research is voluntary: hence, if you decide not to take part of or stop your participation in the research at any time, you will not lose anything, if you have any question about research, you may contact the department of science education, university of Ilorin, Ilorin Nigeria or call researcher on cell phone number: 08034676566

Teacher Response Agreement: I hereby voluntarily consent to participate in the research. I know that I may refuse to participate or stop my participation in the research at

any time. Also, I understand that if I have any question about the research or my right as a student participant, I may contact the Department of Science Education, University of Ilorin, Ilorin, Nigeria, or call the researcher on cell phone number: 08034676566.

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Teacher Participant	Signature	Date

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School Principal	Signature	Date

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Researcher	Signature	Date

APPENDIX XIV

PROVISIONAL BUDGET PROPOSAL

DESCCRIPTION OF ITEM	EXPECTED FROM		
	SPONSOR	STUDENT	TOTAL
Personnel costs/ Allowance		student	20,000:00
Researcher informants			NIL
Technical Assistant (3)		student	30,000:00
Sub Total(not>20%of budget)			52,000:00
Equipment (list & Specify)			
Laptop		student	150,000:00
Printers		student	85,000:00
(1 Color and 2 black and white)			
Flash/modem		student	15,000:00
Generator		student	45,000:00
(Alternative power supply)			
Subtotal (not>20% of budget)			
Supplies Consumables			
Papers/Toners		student	120,000:00
Purchase of textbooks and pen		student	5,000:00
Monthly subscription of			
Modem at N2500 per month		student	75,000:00
X 30			
Subtotal			200,000:00
Data collection of analysis			
Analysis		student	40,000:00
Cost of administering the		student	50,000:00
Tests and the Questionnaire			

Sub Total		90,000:00
Travels		
Researcher	student	200,000:00
Sub Total		200,000:00
Dissemination		
Seminar 1(proposal)	student	30,000:00
Seminal 2(protocol defense)	student	25,000:00
Seminal 3(interim defense)	student	20,000:00
Seminal 4(Oral Defense)	student	300,000:00
Sub Total		
Others/ Miscellaneous		
Accommodation on	student	150,000:00
Research trip		
Miscellaneous	student	120,000:00
Sub Total		270,000:00
GRAND TOTAL		1,405,000:00

APPENDIX XV

Ph.D. Research Schedule and Timeline

MONTH	24/10/2016	24/11/2016	24/12/2016	24/01/2017	24/02/2017	24/03/2017	24/04/2017	24/05/2017	24/06/2017	24/07/2017	24/08/2017	24/09/2017	24/10/2017	24/11/2017	24/12/2017	24/01/2018	24/02/2018	24/03/2018	24/04/2018	24/05/2018	24/06/2018	24/07/2018	24/08/2018	24/09/2018	24/10/2018	24/11/2018	24/12/2018	24/01/2019	24/04/2019	24/05/2019
TASK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Survey of Literature																														
Write proposal																														
Gather Data																														
Thesis Writing																														
Write Introduction																														
Revise Introduction																														
Writing Methodology																														
Revise Methodology																														
Proposal Defence																														
Protocol Defence																														
Results and Discussion																														
Interim report																														
Correction																														
Registration of title																														
Oral examination																														