EFFECTS OF THE 5E LEARNING CYCLEAND SEX ON CHEMISTRY ACHIEVEMENT AMONG SECONDARY SCHOOL STUDENTS IN EDO CENTRAL SENATORIAL DISTRICT

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CERTIFICATION

We, the undersigned certify that this work was carried out by AgbontienChimaKesterin the Department of Curriculum and Integrated Science, Delta State University, Abraka.

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DEDICATION

This work is dedicated to the memory of my late mum, Mrs Vera Agbontien, for her love, care and support towards me while she was yet alive.

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Special thanks go to God Almighty, for life and His grace on my life and also for His mercies and protection throughout the period of my studies.

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ABSTRACT

This study was designed to investigate the effects of the 5E learning cycle and sex on students' achievement in chemistry. Five research questions and five hypotheses guided the study. A quasi-experimental pre and post-test design was adopted while the Chemistry achievement test and the intervention packages for the 5E learning cycle instructional plan and lecture method lesson plan were used as research instrument. Four hundred and twenty-eight (428) secondary school students were used as sample for the study comprising 232 males and 196 females. The mean and standard deviation were used to analyse the research questions while the paired samples t-test, independent samples t-test and Two-Way Analysis of Covariance (ANCOVA) were used to test the hypotheses at 0.05 level of significance. The result obtained showed that there is a significant difference in the pre-test and post-test scores of students taught using the 5E learning cycle; that students taught using the 5E learning cycle perform better than those taught with the lecture method. The findings of the study also showed that the 5E learning cycle impact positively on the chemistry achievement of the students irrespective of their gender and age. Lastly, the study showed that both male and female students do not respond differently to the two teaching methods. Based on the findings of the study, it was recommended, among others, that both government and school heads should advocate the use of the 5E learning cycle in the teaching and learning of chemistry, since it is a better method than the conventional lecture method. Orientation should be given to both students and teachers on the benefits of the use of the 5E learning cycle to the learning of chemistry.

CHAPTER ONE

INTRODUCTION

Background of the Study

The critical role of chemistry in daily life, in industry and society is limitless. Many of our day-to-day activities revolve around chemistry. Chemistry is everywhere; chemistry is life; chemistry is the oracle of modern science (Grosche& Peter, 2013). The importance of chemistry in the development of any nation cannot be underrated especially in Nigeria where the national income rests on petroleum and petrochemical industries. Chemistry is a branch of science which deals with the study of the structure, composition, properties and reactions of matter in different forms. Chemistry is very important in the technological development of the nation. According to Asiyai (2005), Chemistry has helped in the development of modern technology through the application of its principles in modern invention.Despite the key role of chemistry as the central science that forms the basic foundation tomany disciplines and in improving the quality of life, the performance of Nigerian secondary school students in the subject has for many years remained a matter of a serious concern. This has attracted concern of many stakeholders across the country. Efforts made through research to discover the factors affecting students' academic achievement in chemistry disclosed that secondary school chemistry teachers mainly adopt the lecture method in the teaching and learning of chemistry (Udoh, 2008). Research reports reveal that most science teachers use the traditional lecture method in teaching chemistry. This method does not enhance students' academic achievements, especially in the acquisition of process skills (Gbamanja, 1991). In addition, the lecture method is defective because it involves verbal presentation of pre-planned lesson to the students which requires little or no instructional aid and so does not promote students' higher level thinking (Padron & Waxman, 1991). This teaching method is, therefore, teacher-centred, with reduced student participation, since students remain passive during the lesson. For example, students may not be allowed to ask questions or contribute ideas in a lesson involving the use of lecture method (Okoli, 2006). For this reason there is need to search for alternative methodsand the 5E learning cycle looks like an alternative. According to Lovat (2003), "teaching is not an incidental craft to follow naturally from mastery of subject content, but a highly complex blend of theoretical understanding and practical skill". Thus, Eze (2010) opined that the incompetence of the science teacher stems from poor teacher preparation. Learning occurs when learners comprehend concepts and are able to connect them with previous knowledge (Ausubel, 2000). When students learn chemistry meaningfully, their ability to reflect on their own learning and make adjustments accordingly fosters deeper learning.

Deeper learning is the key strategy through which students find meaning and understanding from course material and experiences which in turn may result to competence of knowledge transfer to other domains and how to apply the knowledge in answering questions and resolving problems (Pellegrine& Hilton, 2012). This is referred to as 21st century competencies that are precluded in teaching methods that promote memorization of procedures and recall of facts and principles. In such traditional approaches where the teacher transmits knowledge to passive learners who are seen as "empty vessels" into which knowledge is to be poured, little learning takes place (Vighnarajah, Luan &Abubakar, 2008). Research has shown that students do not enter the classroom as a "blank slate" (Pinker, 2003). Learners construct knowledge by making connections between new information and their existing conceptual framework because "learning is an active process of knowledge construction, the making of connections between existing network of knowledge" (Peterson, Fennema& Carpenter, 2008). According to Bybee (2009), students' prior conceptions, ideas and experiences which they carry to the classroom influence the way they learn new concepts and skills. Hence, it is important that they are actively engaged in the learning process and that they are challenged to reflect on their own learning besides being able to link their prior knowledge to new knowledge.

All through the last century, researchers offered alternative strategies to support meaningful learning in chemical concepts in different countries and there have been different arrangements to active participation of students in biology instruction. Rutherford and Ahlgren (1990) pointed that young people should see, handle, contact, operate and change situations that consent to them to investigate what is happening in science. Since the students need the process skills when doing scientific investigations and during their learning, instructional strategies should be developed so that learners can be active contributors to their learning. One of the teaching strategies based on inquiry is the learning cycle. The learning cycle can be defined as an activity oriented teaching method which promotes students' meaningful understanding of scientific concepts, explore and deepen that understanding, and then apply the concepts to new situations (Walbert, 1997).

The learning cycle is a model which builds on students' prior knowledge but also shifts emphasis from the instructor to the learner and the active role played by the learner in the learning process. It is a pragmatic approach derived from Piaget theory of intellectual development, especially the aspect on mental functioning (Piaget, 1964). According to Bybee (2009), the need to build new knowledge based upon prior knowledge and to connect new and old information was the premise of the 5E learning cycle.The learning cycle model is a teaching procedure consistent with the inquiry nature of science and with the way children naturally learn (Cavallo&Laubach, 2001). Many versions of the learning cycle appear in science curricula with phases ranging in number from 3E to 4E to 5E to 7E. Regardless of the quantity of phases, every learning cycle has at its core the same purpose. In this study, the 5E learning cycle instruction model by Bybee, Gardner, Scotter, Powell, Westbrook and Landes (2006) was used. It requires the instruction of five discrete elements: (a) Engagement: The teacher or a curriculum task assesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. (b) Exploration: Exploration experiences provide students with a common base of activities within which current concepts (particularly misconceptions), processes, and skills are identified and conceptual change is facilitated. (c) Explanation: The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviours.

This phase also provides opportunities for teachers to directly introduce a concept, process, or skill. (d) Elaboration: After receiving explanations about main ideas and terms for their learning tasks, it is important to involve the students in further experiences that extend, or elaborate, the concepts, processes, or skills. This elaboration phase facilitates the transfer of concepts to closely related but new situations. In some cases, students may still have misconceptions, or they may only understand a concept in terms of the exploratory experience. (e) Evaluation: This is the important opportunity for students to use the skills they have acquired and evaluate their understanding. In addition, the students should receive feedback on the adequacy of their explanations. Informal evaluation can occur at the beginning and throughout the 5E sequence. The teacher can complete a formal evaluation after the elaboration phase. This is the phase in which teachers administer assessments to determine each students' level of understanding (Bybee, Taylor, Gardner, Scotter, Powell, Westbrook, &Landes, 2006).

There are many studies carried out to assess the effectiveness of learning cycle (Atay&Tekkaya, 2008). According to these studies, the learning cycle encourages students to develop their own understanding of a scientific concept and so promotes conceptual change while providing better understanding of scientific concepts. Bybee et al., (2006) accredited the 5E learning cycle as an effective model that is based on proven education theories with evidence-based research that supports its use in science classrooms. Pulat (2009) studied the impact of the 5E learning cycle on sixth grade students' mathematics achievement and attitude toward mathematics. The results showed that the students' mathematics achievement improved after the instruction with the 5E learning cycle. Pulat (2009) in AjajaandEravwoke (2013)reported that the use of the 5E learning cycle had statistically significant effect on conceptual and procedural knowledge. Nuhogluand Yalcin (2006) in AjajaandEravwoke (2013)studied the effectiveness of the learning cycle model to increase students' achievement in science subjects, especially in physics and chemistry. The results of this study showed that the learning cycle facilitated students to learn effectively and organize science knowledge in a meaningful way. It was also found to make the knowledge long lasting. Students became more capable to apply their knowledge in other areas outside the original context. Other studies such as Ergin, Kanli and Unsal (2008) have shown significance of the learning cycle as an instructional strategy in enhancing content achievement, retention gains and understanding of chemistry as a science subject. As a model for planning chemistry instruction, the Learning Cycle "helps teachers ‘package’ important instructional goals into a developing conceptual ‘storyline’ that accommodates both selection and sequencing of learning opportunities” (Ramsey, 1993). In doing so, teachers can avoid the use of episodic and fragmented instructional activities or “activitymania” (Moscovici, 1998). The Learning Cycle has been embraced in science teacher education as a suitable approach (Rubba, 1992) consistent with the goals of the National Science Education Standards. Planning chemistry instruction using the 5E learning cycle involves beginning with students’ current knowledge, making connections between current knowledge and new knowledge, providing direct instruction of ideas the students would not be able to discover on their own, and providing opportunities to demonstrate understanding (Bybee, 2009). Tests of the 5E instructional model against other forms of science instruction demonstrate evidence of increased mastery of subject matter, development of more sophisticated scientific reasoning, and increased interest in science, especially chemistry.

On the other hand, sex as a factor in science achievement has generated a lot of concern for science educators. Even if learning opportunities and teaching strategies would be equally effective in chemistry instruction for every boy or girl in class a formal test given at the end of a certain curricular sequence would still yield marked differences between boys, between girls and between boys and girls (Husen, 1999). Ekeh (2003) discovered that male secondary school students performed better than females in science,especially chemistry. Meanwhile, Ocho (1997) observed that female students achieve better than male students in science. Also, Ezeudu (1995) observed that sex has significant effect in favour of females in cognitive achievement. Okwon (2003) observed that sex has no significant effect on students' achievement in science. This shows that there is controversy on chemistry achievement by male and female students. This underscores the need to investigate the effect of sex on students' achievement in chemistry using the 5E learning cycle instruction.

In a study dealing with the effects of the 5E learning cycle on chemistry achievement of secondary school students, the age of the students cannot be neglected. This is because, age has a way of influencing the outcome of the use of any teaching methods in the teaching and learning of chemistry. For instance, Naderi, Abdullah, Aizan, Sharir and Kumar (2005) observe a growing interest in therelationship between creativity, gender, age andacademic achievement of students.

Literature on science education methods in Nigeria indicates that studies on learning cycle instruction in chemistry are scanty and scarce. This implies that there is a general poor knowledge of the learning cycle procedure and its effectiveness in instructional delivery among science educators, researchers and science teachers. This has, therefore, created a gap which requires a very urgent filling in the knowledge of the learning cycle and its use in the teaching of chemistry in Nigerian schools. The purpose of this study, therefore, is to make available and deepen science teacher educators' and secondary school science teachers' knowledge of the effects of learning cycle and sex on chemistry achievement among secondary school students in Edo Central Senatorial District.

Statement of the Problem

Over the years, the teaching of science, particularly Chemistry, has been based on the traditional approach which is the lecture method. The achievements of male and female students in chemistry are usually measured in terms of grades in the senior school certificate examinations and this has not shown any significant improvement over the years. Though academic achievement of students has not shown significant improvement over the years, there has also been a controversy between male and female achievement in science particularly chemistry. This poor achievement among chemistry male and female students in secondary schools in a way indicates an instructional method failure and ineffectiveness. In order to bring about improvement in chemistry achievement among secondary school students and to determine sex effect on chemistry achievement, there is need to introduce and rightly apply more innovative instructional strategies. One of such strategies is the 5E learning cycle. To this end, the general problem of this study is stated in a question form as, will the use of the 5E learning cyclein the teaching of chemistry in secondary schools in Edo Central Senatorial District significantly improve students' academic achievement irrespective of sex?

Research Questions

To guide the study, the following research questions were raised:

1. Is there any difference in the pre-test and post-test scores of students taught with the 5E learning cycle method?
2. Is there any difference in chemistry achievement between students taught with the 5E learning cycle and those taught with the lecture method?
3. Is there any difference in chemistry achievement between male and female students taught with the 5E learning cycle?
4. Is there any difference in chemistry achievement of students taught with the 5E learning cycle based on their age?
5. Is there any interaction effect between method and sex on chemistry achievement?

Hypotheses

The following hypotheses were formulated and tested at the 0.05 level of significance:

1. There isno significantdifference in the pre-test and post-test scores of students taught with the 5E learning cycle method.
2. There is no significant difference in chemistry achievement between students taught with the 5E learning cycle and those taught with the lecture method.
3. There is no significant difference in chemistry achievement between male and female students taught with the 5E learning cycle.
4. There is no significant difference in chemistry achievement of students taught with the 5E learning cycle based on their age.
5. There is no significant interaction effect between method and sex on chemistry achievement.

Purpose of the Study

The general purpose of the study was to determine the effects of the 5E learning cycle and sex on students' achievement in chemistry.

The specific objectives of the study was to investigate:

i if there is any difference in the pre-test and post-test scores of students taught with the 5E learning cycle method;

ii if there is any difference in chemistry achievement between students taught with the 5E learning cycle and those taught with the lecture methods;

iii if there is any difference in chemistry achievement between male and female students taught with the 5E learning cycle;

iv if there is any difference in chemistry achievement of students taught with the 5E learning cycle based on their age; and

v ifthere is any interaction effectbetween method and sex on chemistry achievement.

Significance of the Study

The study is of significance to students, teachers, government, curriculum planners, future researchers and the community in the following ways:

Firstly, the findings of this study willbe useful to the chemistry students. From the findings, the chemistry students might become skilled in constructing new knowledge as a result of the knowledge of learning cycle that this study will bring to their awareness. Both male and female students might become acquainted with the effect of sex on chemistry achievement and this might serve as a major motivation for both sexes to study chemistry without one feeling inferior to the other.

Secondly, the findings of this study will equip chemistry teachers with the systematic procedures for applyingthe 5E learning cycle. This study will expose school teachers to the benefits of using learning cycle in teaching chemistry. The findings of the study might help teachers to plan instruction in such a way that both male and female students will learn new concepts at their own pace by following systematically all the phases of the 5E learning cycle.

Thirdly, the findings of this study will help curriculum planners in the areas of curriculum planning and development that will feature teaching through the use of the 5E learning cycle.Also, the results and suggestions of this study may guide the government to formulate and adopt policies geared towards effective teaching of chemistry through the use ofthe 5E learning cycle as a more effective innovative method of teaching chemistry.

Finally, the results and suggestions of this study will form reference points for future researchers. The findings of the study might serve as reference materials for all those who might be interested in carrying out a study on the effects of guided inquiry instructional strategy and sex on students' achievement in other science subjects.

Scope and Delimitation of the Study

This study investigated the effects of the 5E learning cycle and sex on students' achievement in chemistry among senior secondary (SS II) in their second term.

This study wasdelimited to all the senior secondary school II (SS II) students in Edo Central Senatorial District. This included all the science students offering chemistry in the Senatorial District.

Limitations of the Study

The researcher was faced with many problems in the course of this study. Some of the students, especially in the rural schools, were unable to read chemistry problems.

One of the research assistants that were trained by the researcher to assist the researcher during treatment relocated to another State. This increased the duration of treatment as the researcher had to train another research assistant to replace him.

Also, the study was restricted to only a few Senior Secondary Schools. Only 10 Senior Secondary Schools were selected for the study out of 67 Senior Secondary Schools in Edo Central Senatorial District due to distance between schools. Thus, it was not possible to carry out the study using all the Senior Secondary Schools in the Senatorial District.

Operational Definition of Terms

The terms and concepts that are commonly used in this study are hereby operationally defined as follows:

Learning Cycle: This refers to an activity oriented teaching method that can promote students meaningful understanding of scientific concept, explore and deepen that understanding, and then apply the concepts to new situations.

5E learning cycle: This refers to the learning cycle that is made up of five steps which are engagement, exploration, explanation, elaborating and evaluation.

Instructional Strategy: This is a process by which an entire instruction module or an entire lesson is delivered and which may include demonstration, discussion and lecture. It is also called technique of delivery.

Achievement in Chemistry: This is the same thing as chemistry achievement.It refers to the respective students' attainments or scores having participated in a test or examination.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

The review of related literature is organized along the following sub-headings:

- Theoretical Framework of the Study
- The Teaching and Learning of Chemistry
- The Concept of Learning Cycle in Teaching Science
- The Role of the Learner and the Teacher in the 5E learning cycle in the Teaching of Chemistry
- Advantages and Disadvantages of the 5E learning cycle
- Empirical Studies on Effects of the 5E learning cycle on Students Achievement in Chemistry
- Sex and Students Achievement in Science
- Empirical Studies on Effects of Sex on Students Achievement in Chemistry.
- Appraisal of the Reviewed Literature

Theoretical Framework of the Study

The theoretical framework of the study is based on Bruner's Constructivist Theory. Bruner was one of the founding fathers of the constructivist theory. Constructivism is a broad conceptual framework with numerous perspectives, and Bruner's is only one.Bruner's theoretical framework is concerned with the belief that learners construct new ideas or concepts based upon existing knowledge (Bruner, 1996). Bruner believes that learning is an active process. Bruner emphasized the role of structure in learning and how it may be made central in teaching. Structure refers to relationships among factual elements and techniques. He introduced the ideas of "readiness for learning" and spiral curriculum. Bruner believed that any subject could be taught at any stage of development in a way that fit the child's cognitive abilities. Spiral curriculum refers to the idea of revisiting basic ideas over and over, building upon them and elaborating to the level of full understanding and mastery.

Bruner believed that intuitive and analytical thinking should both be encouraged and rewarded. He believed intuitive skills were under-emphasized and he reflected on the ability of experts in every field to make intuitive leaps. Bruner’s Constructivist Learning theory falls into the cognitive domain. Learners are considered to be creators and thinkers through the use of inquiry, and the role of experience in learning. The process of how learners construct knowledge rather than the output of information is heavy in focus. Opportunities are provided for learners to construct new knowledge and new meaning from authentic experiences. Burner’s Constructivism can be applied to subject matter across many different curriculums that yield the time to process results. The results are not controlled solely by the learner or the instructor. Each of them has specific roles in instruction that allow the learner to develop meaningful knowledge of the subject matter.

Usually learners control the process of learning due to the authentic nature coupled with initial environmental predispositions. Input and structure provided by the teacher for instruction through the appropriate environment for learners, results in the construction and rationalization of newly formed understanding of concepts and knowledge. Bruner developed a method of teaching called Discovery Learning which utilizes his theory of constructivism. The traditional classrooms can incorporate Bruner's theory of Constructivism in a number of ways. Learning cycle is one way that science teachers can make use of the theory since the theory itself is scientifically inquiry-based. Meanwhile, the learning cycle is a generic term used to describe any model of scientific inquiry instructional strategy that encourages students to develop their own understanding of a scientific concept, explore and deepen that understanding and then apply the concept to new situations. Assessments in school systems would become more learners centred if Constructivist approaches are adopted. The learner would progress at his or her own rate from one step of learning cycle to another while fully understanding concepts presented by the instructor. Although his concepts are different than that of traditional instruction, due to the benefits and gains it is possible to see a greater shift towards the Constructivist framework over time. Bruner believes that knowing is a process and so his work focused on the importance of understanding the structure of a subject being studied, the need for active learning as the basis for understanding, and the importance of creating new concepts during learning. Bruner believes that when learners are faced with difficult challenges they will want to provide a suitable solution. This is the premise which this study is based on since learning cycle instructions are designed towards making the learner construct new knowledge and provide solutions to scientific problems.

The Teaching and Learning of Chemistry

There is now a significant body of knowledge about teaching and learning of chemistry. All teachers know that what is taught by teachers is not the same as what is learnt by students. As in all acts of communication, learners have to make sense of what they hear, see and read in terms of what they already know. Teachers can make this easier or more difficult for students by the way these messages are put together, and the way that students' questions are elicited and answered (Orsborne& Collins, 2001). This fundamental insight, that learning involves individuals in actively responding to information and its situation, has been developed into several theoretical perspectives which have been used to inform the planning of teaching of chemistry as a science subject. A recent example involves the design and evaluation of short science teaching sequences in the early years of secondary education (Driver, Asoko, Leach, Mortimer, & Scott, 1994). Drawing upon a social constructivist perspective on learning, insights about the treatment of content and patterns of teacher talk were built in to the design of such sequences. Evaluation evidence shows that students' understanding was significantly better when they followed these teaching sequences than it would have been had they followed their school's usual teaching programmes. There is very strong empirical evidence that some of the fundamental concepts on which scientific understanding is built are commonly misunderstood by learners, and that there are patterns in the difficulties that they experience. For example, when first encountering explanations of the behaviour of simple electrical circuits consisting of components connected in series, many learners use a source-consumer model inappropriately, with the result that they can't accept that the current is the same at any point in the circuit (Ogborn, Kress, Martins, &McGillicuddy, 1996). Several ways of addressing this difficulty have been designed and evaluated, with positive results. Evidence of this kind is useful in identifying key conceptual difficulties that are likely to be experienced by students at specific points in the science curriculum. Usable tools for addressing those difficulties can be developed. The insights that come from the research do not lead to simple prescriptions of ‘what works’ and what science teachers should therefore be made to do. But research can inform chemistry teachers as they plan how to tackle difficult content in a way that their students understand, and can help guide their conversations with students during teaching.

Significant work has also been conducted on the effects of several teaching methods on students’ academic achievement. Nwachukwu (2005) investigated the effect of use of cooperative and competitive interaction strategies in teaching chemistry on Nigerian secondary schools. The research revealed that the two strategies are superior to the conventional practices in Nigeria. Infact, the female students outperformed the males in cooperation whereas the males outperformed the females in competition. Also, Nwachukwu (2009) investigated the use of concept mapping in teaching biology in Nigerian Secondary schools. The study revealed that use of concept mapping enhanced the acquisition and retention of biology better than the conventional practices. The problem with Nigerian educational sector is that education research findings are not utilized for the education benefit of the masses. Hence, problems in science education continue unabated. No one single method is best for the teaching of chemistry, and that it is the responsibility of the teacher to find out the best approach to conduct his lesson. Teachers who properly understand and appreciate chemistry as a science subject and reasons for teaching chemistry are conversant with the best methods for achieving the goal. Below are some of the approaches for teaching chemistry as a science subject;

Student Centred Approach: As the centre of all learning and teaching revolve around the student, it would be unwise if the teaching method fails to recognize the central position of the student and hence due attention paid to the student. In this method the student is considered to be foremost and all his interests are therefore served. The teacher then direct the teaching to serving the student best so that he comes out to be a good and useful citizen with all round education. This type of teaching recognizes the needs values and importance of the student as the centre post of all teaching. The teaching method based on the students' centred approach allows the involvement of the student in an open ended laboratory exercise. According to Ehiametalor (1982), the informal method consists of spontaneous discussion, planned discussion, advisory approach, panel discussion, small group discussion, seminar, debate, committee and group work, problem solving research, case study and so forth.

Inductive Approach: The knowledge of the past can best be used to develop the knowledge of the future. According to Okpala (2006), the inductive method begins from specific to general, known to unknown, and concrete to abstract. To study any basic concept it is wise to first study the definition and all those issues leading to it. Okpala (2006) observes that inductive method is a method of discovering. The inductive method provides an opportunity for students to discover new concepts, laws, truths and new methods of solving a particular problem or finding solutions to problems in chemistry.

Process Approach: According to Ikeobi (1990) process approach is one of the best ways to teach chemistry. The students are taken out to observe natural things relating to chemistry. Thus process approach involves active participation by all students. This makes the students feel at their best instead of finding the lesson boring or dozing in the normal class-room situation. This method allows the students to feel, touch, see, smell and enquire into things they see.

Student Motivation Approach: Researchers are of the opinion that quality teaching is found in the school and it is being carried out by qualified teachers who can motivate students to learn under diverse conditions. Motivation is regarded as one of the qualities of achieving good teaching and learning in schools. According to Marshall (1987), students' motivation to learn can be defined as meaningfulness value, and benefits of academic tasks to the learner regardless of whether or not they are intrinsically interesting. Nwachukwu(2009), states that students are more effective learners if they are intrinsically motivated towards learning than if they are extrinsically motivated. When students are well motivated it makes teaching/learning to be effective. The appropriate motivational techniques should be used to arouse the interest of students towards chemistry learning. Also, the use of appropriate disciplinary measures by teachers can motivate the students to learn. A teacher should be a good role model for the students to emulate. A keen and competent teacher is always certain of good response. He should be punctual and regular to class so as to encourage the students to learn. A teacher who is always punctual in class will through this action encourage even the most perpetual late comer to keep to time for classes. The teacher should make sure the class is well controlled otherwise teaching will be ineffective.

Socratic Approach: This approach involves the use of questions to elicit the hidden idea of the students. The students are asked questions to know how far they have acquired the necessary knowledge and skills imparted to them. This questioning method or Socratic Method is a good method of testing the

Research in Education and Society knowledge of the students. It also gives the student the opportunity to demonstrate what they have acquired before or how far they have mastered the imparted new knowledge. According to Okpala (2006), this method helps in building sense of self-expression in the students and also serves as means of giving practical experience and awareness. This method, if properly applied, has proved to have immense advantages over the lecture method of teaching chemistry.

For teaching to be effective in promoting learning, it must involve interaction between teachers and students. One-way delivery from a teacher does not work for the vast majority of pupils. Thus, all the methods and approaches of teaching chemistry described above emphasize the active role of the Learner in the teaching and learning of chemistry. The approaches underscore the importance of guided inquiry instructional strategy since this method also emphasizes the place of the learner in constructing and creating new knowledge for themselves. Meanwhile, the 5E learning cycle is an inquiry based approach for teaching and learning of chemistry.

The Concept of Learning Cycle in Teaching Science

The learning cycle can be defined as an activity oriented teaching methods and promote students meaningful understanding of scientific concept, explore and deepen that understanding, and then apply the concept to new situations (Walbert, 1997). The learning cycle is a model which builds on students' prior knowledge but also shifts emphasis from the instructor to the leaner and the active role played by the leaner in the learning process. It is a pragmatic approach derived from Piaget theory of intellectual development especially the aspect on mental functioning (Piaget, 1964). The Learning Cycle was developed in 1967 by Karplus and Thier for the *Science Curriculum Improvement Study* (SCIS). The learning cycle is an inquiry-based teaching-learning approach that is based on three distinct phases of instruction which include:

1. **Exploration,**which provides students with firsthand experiences with science phenomena.
2. **Concept Introduction,**which allows students to build science ideas through interaction with peers, texts, and teachers.
3. **Concept Application,**which asks students to apply these science ideas to new situations or new problems.

Since Karplus and Thier introduced the Learning Cycle, several variations including different numbers of phases ranging from 3E to 7E have been proposed. However, regardless of the number of phases they include, "each new version retains the essence of the original Learning Cycle - exploration before concept introduction" (Brown &Abell, 2007). A popular version of the Learning Cycle is the 5-E model which is made up of the following phases; Engage, Explore, Explain, Elaborate, Evaluate (Bybee, 2009). It incorporates the three original Learning Cycle phases while adding two more: the Engage phase of the 5-E is designed to captivate students' attention and uncover their prior knowledge about the concept(s), while the Evaluate phase is an opportunity for the teacher to assess students' progress, as well as for students to reflect on their new understandings.

There has been a large amount of research concerning the Learning Cycle approach since its origins in the 1960's. Much of the research supporting the Learning Cycle approach is discussed in detail in Lawson, Abraham & Renner (1989) cited in Gerber, Cavallo, and Merrick(2001) and supports the conclusion that the Learning Cycle approach can result in greater achievement in science, better retention of concepts, improved attitudes toward science and science learning, improved reasoning ability, and superior process skills than would be the case with traditional instructional approaches.

As a model for planning science instruction, the Learning Cycle "can help teachers 'package' important instructional goals into a developing conceptual 'storyline' that accommodates both selection and sequencing of learning opportunities" (Ramsey, 1993). In doing so, teachers can avoid the use of episodic and fragmented instructional activities or "activitymania" (Moscovici, 1998). The Learning Cycle has been embraced in science teacher education as a suitable approach (Rubba, 1992) consistent with the goals of the *National Science Education Standards* (NRC, 1996).

The concept behind the 5E model is to begin with students' current knowledge, make connections between current knowledge and new knowledge, provide direct instruction of ideas the students would not be able to discover on their own, and provide opportunities to demonstrate understanding (Bybee 2009). The 5E Model has been used since the 1980s in elementary, middle, and high school science curricula. Tests of the 5E instructional model against other forms of science instruction demonstrate evidence of increased mastery of subject matter, development of more sophisticated scientific reasoning, and increased interest in science. After working with students during the 'Evaluate' step (formative assessment), a teacher can then use the results to make instructional decisions: differentiating instruction by challenging students who are ready for more, or intervening for students who need a different approach or a modified presentation of the content.

The learning cycle that will be used in this study follows Bybee (2009) five steps of Engagement, Exploration, Explanation, Elaboration and

Evaluation. An explanation of each step of the 5E learning cycle is shown below-

Engagement: The Engagement phase of the 5E Model is the attempt to activate prior knowledge to discover student preconceptions. Preconceptions, misconceptions or naïve conceptions are prevalent in our society and are often immune to traditional instruction. Many people, for example, attribute the change of seasons to Earth periodically moving closer and farther in distance from the sun, rather than to the changing tilt of Earth on its axis. Prior knowledge has been shown to be a major factor in comprehension in any subject. Effective instruction must take into account the knowledge that students already have. In science, when students reveal their prior knowledge, any naïve conceptions are exposed. Recent work in using prior knowledge at the base of an analogy for a lesson's science concept helps to build understanding throughout the lesson and has been shown to be highly effective in developing science expertise (Stephens &Clement, 2008). There are many ways to activate prior knowledge including:

i. Brainstorming (listing information solicited from students).

ii. Asking specific questions and noting responses.

iii. Engaging students in a problem, activity, or scenario to elicit what they know. Engage students with "What do you think?" anticipation guide found at the beginning of each Chapter or in the inquiry-based discussions related to images.

Exploration: The Exploration phase of the 5E model challenges student preconceptions. "Creating an opportunity to challenge our students to call on their collective experiences (prior knowledge) is essential. Through this process we move students from memorizing information to meaningful learning and begin the journey of connecting learning events rather than remembering bits and pieces. Prior knowledge is an essential element in this quest for making meaning (Christen & Murphy 1991).Four conditions need to be present in order for students to undergo a conceptual change, according to Mestre (1994). These are -

i. Student dissatisfaction with an existing conception. (If an explanation makes sense to the student and is unchallenged, there is no motivation to change it)

ii. Students must have some minimal understanding of the concept or they will not appreciate its meaning.

iii. Students must view the new concept as plausible or they will not give it serious consideration.

iv. Students must see the new concept as useful for interpreting or predicting phenomena.

To create these conditions, teachers must do the following -

- Listen to student ideas to identify misconceptions.
- If misconceptions are identified, promote dissatisfaction by challenging students; they can do this by providing evidence that illustrates inconsistencies between student beliefs and scientific phenomena.
- Inspire debate about the evidence to help students appreciate the value of the scientific conception in terms of its consistency with other concepts and phenomena.
- Help students to reconstruct their knowledge.
- Through exploration - including discussion, demonstration, and hands-on activities - teachers can challenge student conceptions.

Explanation: The Explanation phase involves presenting information that students are unlikely to discover on their own and allows for students to demonstrate skills, knowledge, or behaviour. This phase provides the teacher the opportunity to address concerns that students might miss the point of the lesson, may experience cognitive overload, or - without instruction - might even develop misconceptions. “The past half-century of empirical research has provided overwhelming and unambiguous evidence that minimal guidance during instruction is significantly less effective and efficient than guidance specifically designed to support the cognitive processing necessary for learning” (Krischner, Sweller& Clark, 2006).Furthermore, a foundation of knowledge is critical to developing expertise (Bereiter&Scardamalia 1993). Without the explanation and relaying of content knowledge, many students, particularly weaker students will not benefit from the lesson or activities, no matter how engaged they are.

Elaboration: Elaborating on content is the next phase of the 5E Instructional Cycle. This phase reflects Elaboration Theory, which emerged from Cognitive Learning Theory. The premise is that for the most effective learning to take place, instruction should be organized in increasing order of complexity. The idea is that students need to develop a meaningful context into which new learning can be connected. Background knowledge can be reinforced and naïve conceptions further challenged through revisiting and elaborating on the lesson concepts. This also allows more intricate concepts to be introduced (Reigeluth, 1999). In this phase of the 5E Instructional Model, supporting content - including information, understandings, and skills that are directly relevant but have not been addressed can be elaborated on.

Evaluation: Evaluation is a critical phase of any instructional model. The purpose of formativeassessment during instruction is to provide information about student understanding and performance to enable the teacher to make course corrections as need be, based on sound, defensible decisions (Anderson, 2003). A summativeassessment following instruction provides for evaluation of performance, but can also inform the instructor about how to manage subsequent lessons. A key factor in any assessment is that it is valid: that it enables the instructor to gauge if and how students are meeting the lesson objectives. Evaluations may take the form of quizzes, tests, observations of performance, writings, interviews, or some other form. Without a valid assessment, neither instructors nor students can be confident that objectives are being addressed and met.

In general, the learning cycle as an instructional model that provides active learning experiences and it is recommended by the National Science Education Standards (National Research Council, 1996). Therefore, it is important to study the effect of the 5E learning cycle on chemistry achievement among secondary school.

The Role of the Learner and the Teacher in the 5E learning cycle in the Teaching of Chemistry

This session deals on the role of the teacher and the learner in effective the 5E learning cycle going from step to another as described below -

The Role of the Teacher and the Learner in Engagement Stage: In this stage, the teacher creates interest and generates curiosity in the topic of study. For this reason activities are made. These activities help students to make connections with the previous knowledge. The teacher raises questions and elicits responses from the students that will give you an idea of what they already know. Teacher has also a good opportunity to identify misconceptions in students' understanding. During this stage students ask questions such as why did this happen? How can I find out?

The table below describes both teachers and students role in the engagement phase.

Table 1 The Role of Students and Teachers in the Engagement Phase of the 5E learning cycle Model

STUDENT	TEACHER
Calls up prior knowledge	Poses problems, generates curiosity
Shows interest in the topic.	Raises questions, creates interest
Experiences doubt or disequilibria	Reveals discrepancies

Asks questions such as: "Why did thishappen? "What can I find about this?"	Causes disequilibria or doubt
Identifies problems to solve, decisionsto be made, conflicts to be resolved	Elicits responses that uncover what thestudents know or think about the concept/topic

The Role of the Teacher and the Learner in Exploration Stage: In exploration stage, students are given opportunities to work together without direct instruction from the teacher. Students get directly involved with phenomena. The teacher's role in the exploration phase is that of a guide, a coach and a facilitator. Students are puzzled. This is the opportunity for students to test predictions and hypotheses and/or form new ones, try alternatives and discuss them with peers, record observations and ideas and suspend judgment. The table below describes the teacher and the student role in exploration stage

Table 2: The Role of Student and Teacher in the Exploration Phase of the 5E learning cycle Model

STUDENT	**TEACHER**
Tests predictions and hypotheses.	Encourages students to work without direct instruction from the teacher.
Tries alternatives and discusses them with others.	Ask probing questions to redirect students' investigations when

	necessary.
Thinks freely, but within the limits of the activity.	Provides time for students to puzzle through problems.
Forms new predictions and hypotheses.	Acts as a consultant for students.
Records observations and ideas.	Observes and listens to students as they interact.
Suspends judgement.	Provides time for students' investigations when necessary.

The Role of the Teacher and the Student in Explanation Stage: During explanation, teacher helps students make sense of their observations and questions arise from their observations. The teacher encourages students to explain concepts in their own words, ask for evidence and clarification of their explanation, and listen critically to one another's explanation and those of the teacher. Students are required to use observations and recordings in their explanations. Then, the teacher introduces a scientific explanation for the event through formal and direct instruction. The teacher connects the scientific explanation with the physical evidence from exploration and engagement and also relates it to the explanations that the children have formed. Besides the verbal methods, the teacher might also use videos, books, multimedia presentations, and computer courseware. The table below describes the role of the teacher and the student in explanation stage.

Table 3: The Role of Student and Teacher in the Explanation Phase of 5E Learning

STUDENT	TEACHER
Explains possible solutions or answers to the others.	Provides feedback
Shares understandings for feedback	Ask questions, poses new problems and Issues
Seeks new explanations.	Enhances or clarifies explanations
Forms generalizations	Uses students' previous experience as the bases for explaining concepts
Uses recorded observations in explanations.	Evaluates explanations
Reflects on plausibility	Offers alternative explanations

The Role of the Teacher and the Student in Elaboration Stage: During "Elaboration" students apply concepts and skills in new (but similar) situations and use formal labels and definitions. Students expand on the concepts they have learned, make connections to other related concepts, and apply their understanding to the real world around them. Elaboration strategies apply here as well because students should be using the previous information to ask questions, propose solutions, and make decisions, experiment, and record observations. This phase often involves experimental inquiry; investigate projects, problem solving and decision making. The teacher may decide to recycle through different phases of the 5E learning cycle to improve students' understanding or move on to new science lessons. Table four describes the role of the teacher and the student in the Elaboration stage.

Table 4: The Role of Student and Teacher in the Elaboration Phase of the 5E learning cycle Model

STUDENT	TEACHER
Draw reasonable conclusions from evidence	Encourages students to apply or extend the concepts and skills in new situations.
Records observations, explanations, and reasonable conclusions from evidence.	Refers students to existing data and evidence and asks: "Why do you think…?" "What do you already know?"
Check for understanding among peers.	Expects students to use formal labels, definitions, and explanations provided previously.
Applies new labels, definitions,	Reminds students of alternative

explanations, and skills in new, but similar, situations.	explanations.

The Role of the Teacher and the Student in Evaluation Stage: Evaluation should take place at all points along the continuum of the instructional process. Teacher observes students' knowledge and/or skills, application of new concepts and a change in thinking. Teacher may be using also rubrics, student interviews, portfolios designed with specific purposes, project and problem-based learning products, and concept maps. Students should assess their own learning. Teacher asks open-ended questions and look for answers that use observation, evidence, and previously accepted explanations. Students are also asked questions that would encourage future investigations. The table below describes the role of the teacher and the student in evaluation stage

Table 5: The Role of Student and Teacher in the Evaluation Phase of the 5E learning cycle Model

STUDENT	TEACHER
Evaluates her/his own progress and knowledge	Assesses students' knowledge and/ or skills.
Answers open-ended questions by using observations, evidence, and previously accepted explanations.	Allows students to assess their own learning and group- process skills.
Asks related questions that would encourage future investigations.	Observes students as they apply new concepts and skills.

Demonstrates an understanding or knowledge of the concept or skill.	Looks for evidence that students have changed their thinking or behaviours. Asks open-ended questions such as "What do you know about x?", "Why do you think...?", "How would you explain x?"

According to several researches, the 5E learning cycle is an effective teaching strategy and enhances students' understanding and achievement. In their study, Bevenino, Dengel and Adams (1999) stated that the 5E learning cycle encourages students to develop their own frames of thought. Similar results can be seen in the study of Colburn and Clough (1997). They examined that the 5E learning cycle is an effective way to help students enjoy science, understand concept and apply scientific process and concepts to authentic situations.

Advantages and Disadvantages of the 5E learning cycle

Learning cycle enhances the retention of science knowledge and makes knowledge long lasting. It enables students become more capable of applying their knowledge in other areas outside the original context (Nuhoglu&Yalcin, 2006).The major advantage of the 5E learning cycle apart from other advantages associated with constructivist approaches to instruction is the creation of learning opportunities for students (Moyer, Hackett & Everett, 2007). The approach offers students the opportunity to perform physical activities designed to answer questions raised by the teacher and the students and at the same time engages them mentally. The approach may therefore be very appropriate for teaching for conceptual change.

Two major limitations can be identified with the 5E learning cycle. Firstly, the method is time consuming. A method of instruction which involves as many as five stages may not be very suitable for achieving immediate lesson objectives. Secondly, field dependent and low ability students who most often dependent on teachers for all information and directives may experience some difficulties using the approach for learning. However, these two limitations may be reduced through increasing instruction time for science subjects and re-emphasizing strong cooperation among students when the method is used.

Empirical Studies on Effects of the 5E learning cycle on Students' Achievement in Chemistry

Literature on the 5E learning cycle indicates that it rests on constructivism as its theoretical foundation; constructivism is a dynamic and interactive model of how humans learn (Bybee, 2009). A constructivist perspective assumes students must be actively involved in their learning and concepts are not transmitted from teacher to student but constructed by the student (Nuhuglu&Yalcin, 2006). Numerous studies have shown that the 5E learning cycle as a model of instruction is far superior to transmission models in which students are passive receivers of knowledge from their teacher (Bybee, 2009).

As a curriculum framework, the 5E learning cycle provides experiences from which learners construct meaning (Nuhuglu&Yalcin, 2006). Nuhuglu and Yalcin (2006) studied the effectiveness of the 5E learning cycle model to increase students' achievement in the science laboratory. The results of this study showed that the 5E learning cycle facilitated students to learn effectively and organize the knowledge in a meaningful way. It was also found to make the knowledge long lasting. Students became more capable to apply their knowledge in other areas outside the original context.

Pulat (2009) studied the impact of the 5E learning cycle on sixth grade students' mathematics achievement and attitude toward mathematics. The results showed that the students' mathematics achievement improved after the instruction of the 5E learning cycle. Hiccan (2008) reported that the use of the 5E learning cycle had statistically significant effect on conceptual and procedural knowledge. Studies by (Baser, 2008; Whilder&Shuttleworth, 2004; Lee, 2003) made similar findings.The study by Lee (2003) found that the students acquired knowledge about plants in daily life easier and understood the concepts better – when taught with the 5E learning cycle.

Literature on the effect of the 5E learning cycle on attitude towards science especially, chemistry indicated a general improvement in students' attitude when taught with the 5E learning cycle. Lord (1999) compared the effects of the 5E learning cycle instruction with the traditional instruction in environmental chemistry. The participants were college undergraduates. It was found that while the control group students found the lessons boring, the experimental group students found them interesting and had a lot of fun. A study carried out by Kaynor(2007) on the effect of 5E on attitude towards science indicted that although there were attitude gains towards science by the experimental groups but the gains were not significant.

Furthermore, studies by Ajaja (1998) and Nuhuglu and Yalcin (2006) found that the 5E learning cycle enhanced retention of Science knowledge. Specially, Nuhuglu and Yalcin(2006) stated that the 5E learning cyclemakes science knowledge to be long lasting in the mind of the learner. They further stated that students become more capable to apply their knowledge in other areas,especially in the subject area of chemistry.

Sex and Students' Achievement in Science

In the society today, female students are seen to have more experiences with bread-making, sewing and planting seeds. Male students are seen to show more interests in science and scientists' jobs than females. Explanatory factors for sex differences in science performance have been explored. Large advantages for boys on the subject of physical science and a modest advantage for girls in life science have been noticed. The role of sex in chemistry performance, and other subject areas in general, has precipitated a variety of studies over time and will no doubt continue to do so. A study by Boli, Allen and Payne (1985) explored the reasons behind the differences that were observed between sex in undergraduate chemistry and mathematics courses. Their exploration sought reasons behind why male students were tending to outperform the female cohort, resulting in the suggestion that differences in mathematical ability were a very important consideration. The most important factor, through an analysis of previous studies, was that the male students' natural self-confidence and belief in the importance and need for mathematics had a positive influence on male performance. These findings with regard to mathematics can be fairly evenly transferred to the natural sciences (Boli, et al, 1985). Other than mathematics, there appeared to be no directly sex-related reasons for the male students outperforming the female students yet the evidence showed that this was the case. The study also showed that females were less likely to choose mathematics and science courses at the undergraduate level, often because of lesser preparation at the prior levels of schooling (Buccheri, Gurber&Bruhwiler, 2011). Many studies have agreed with the observation that male students usually outperform female students in assessments particularly in the areas of mathematics and science.

Males and females have similar opportunities and skills which are important to be directed to improve the learning of science. Sex and science education is a vital issue; sex interacts in significant ways with other social variables and must be taken into consideration (Atwater, 2000;Rennie, 2000). A range of beliefs and experiences along the intersection of professional and personal identities, views of the nature of science, beliefs related to students' experiences in science education, and kinds of curricula and instructional strategies were used to promote access and equity for all students. Bias against minorities and women is still a problem in science education, and it needs more work to be improved (Bianchini; Cavazos; Helms, 2000).

A number of studies have found that boys' achievement in science is significantly better than that of girls. Levin, Sabar and Libman (1991) found that the achievement of boys in all subject area of their study (earth science, biology, chemistry and physics) was significantly better than the achievement of the girls.

Achievement test results over the years have shown an ever increasing gap between the performances of boys and girls in chemistry at senior secondary school level (Onekutu&Onekutu, 2002). In fact, girls now tend to ignore the subject all together. This has resulted to a situation where there are more boys than girls doing chemistry at this level. As a result, chemistry classes and science classes in general are dominated by boys while the girls go into reading languages and Arts. The perceived low achievement of girls in chemistry is an unpleasant development as it spells doom for those of them who would like to pursue careers in the sciences. This is because a pass at credit level in chemistry is required at Senior School admission into science programmes in the universities.

Many research studies have been carried out about the underachievement of females in the sciences. These include those of Duncan (1999) and Greenfield (1996), as cited in Eriba and Ande (2006)they found that male students were superior in the sciences than their female counter parts. According to Gipps (1994) and O'Connor (2001), as boys and girls grew up, the differences they have in achievement in other subjects tend to diminish except in the sciences, and mathematics. The fear of Mathematics is often transferred to Chemistry, which involves one form of calculation or the other (Obande, 2003). However, it is not all aspects of Chemistry that involve calculations. It is mostly topics in Physical Chemistry and the Kinetic theory of gases. Williams and Jacobson (1990) agree that in early school years there is no difference in the achievement of boys and girls in the sciences but that in the higher classes, the boys perform better than the girls in the areas that have to do with calculations. Onekutu andOnekutu (2002) opined that to be able to communicate appropriately in science, one needs the ability to use graphs, symbols and diagrams. All these are in mathematics and this seems to be where the girls have fallen short.

Gabel andSherwood (1994) were however, not in total agreement with the above statement and claimed that underachievement of students in calculating reacting masses from chemical changes was not due to the fear of mathematical content, but due to the fact that majority of the students did not understand the basic concepts involved in the study of the topic. According to UNESCO (1998), local customs and values have been developing in girls and they are so deeply ingrained that women themselves often subscribe to them and play a subservient role in the society. Lie (1994) observed that invincible rules within the society have provided what is feminine and what is masculine. Hence, science in most cultures is defined as a masculine domain (Onekutu&Onekutu, 2002). The situation today has degenerated such that girls now completely see Science subjects as a male-only endeavour, preferring to go for other subjects. It is therefore very important to carry out a study of the effect of sex on chemistry achievement among secondary school students in Edo Central Senatorial District.

Empirical Studies on Effects of Sex on Students' Achievement in Chemistry

Even if learning opportunities and teaching strategies would be equally effective in chemistry instruction for every boy or girl in class a formal test given at the end of a certain curricular sequence would still yield marked differences between boys, between girls and between boys and girls (Husen, 1999). Akala (2010) carried out a study on gender differences in students' achievement in chemistry in secondary schools.The study was a cross-sectional descriptive survey employing correlational methods to investigate gender differences in chemistry achievement levels of girls and boys. The study comprised twelve (12) stratified selected public secondary schools in Kakamega district. A total of 386 students responded to a five-item, chemistry Achievement Test (CHAT) comprising descriptive, mathematical and spatial ability items. Quantitative data obtained from the

CHAT were analysed using Statistical Package for Social Sciences (SPSS). The study revealed that gender was strongly associated with Chemistry achievement ($r = 0.9880$, $\alpha > 0.001$). As a result, boys' schools performed better than girls schools. Boys had a stronger affinity and interest towards Chemistry. Alaka (2010) stated that teacher and school factors were of little effect on Chemistry achievement with respect to gender. These empirical studies were in line with that of Ekeh (2003) who discovered that male secondary school students performed better than females in science especially chemistry. Also, the National Assessment of Educational Progress in 1992 showed that males had higher average scores than girls between the ages of 9, 13 and 17. However, Udousoro (2011) investigated the effects of gender and mathematics ability on academic performance of students in chemistry. The sample size comprised one hundred (100) SS 1 chemistry students in two secondary schools in Uyo metropolis. The instruments used were the Chemistry Achievement Test (CAT) and the Mathematics Ability Test (MAT). Independent t-test statistical tool was used to analyse the data collected. The result of the test indicated that gender does not have any significant effect on the academic achievement of students in Chemistry. This shows that there is still a controversy on students' sex as it affects their academic achievement. Thus, it is imperative to carry out further studies on the effect of sex on students' achievement especially in chemistry.

Qarareh (2012) conducted a study on the effect of using learning cycle method in teaching science on the educational achievement of the sixth graders. Eighty students were randomly selected then divided into two groups- the experimental group which was taught by using the learning cycle, and the control group which was taught by the traditional method. Data were collected using the following two instruments: a number of teaching situations which were planned by learning cycle and achievement test. To answer the questions, t-test was used. The study revealed that there is no statistically significant differences in the achievement of students in difference age groups. According to him, age of the students will not affect their achievement when taught using learning cycle methods of teaching.

Appraisal of the Reviewed Literature

The review of literature revealed related researches carried out by other researchers. From the review, the 5E learning cycle has been proved effective in the teaching and learning of some subjects like biology, mathematics, physics and even chemistry. Some empirical studies as reviewed in this chapter showed that the use of the 5E learning cyclehas a positive effecton students' achievement in biology, mathematics, physics and chemistry as science subjects. Most of these studies were carried out in other states of Nigeria and particularly other Senatorial Districts of Edo State have been used as a case study. Take for an instance, AjajaandEravwoke (2013) studied the effect of the 5E learning cycle on students' achievement in biology and chemistry. This study revealed that the 5E learning cycle has a positive effect on students' achievement in biology and chemistry but the study was limited to only Ethiope East Local Government Area of Delta State. AjajaandEravwoke (2013) stated that situation therefore calls for education of science teachers on the procedures of learning cycle and a demonstration of its effectiveness in science teaching and learning. Meanwhile, to the knowledge of the researcher, a study of this kind has not been carried out using Edo Central as a case study. It is on this basis the researcher seeks to further investigate the effect of the 5E learning cycle on students' achievement in chemistry using Edo Central Senatorial District as a case study. Also, the review of literature showed that sex as it affects academic achievement in chemistry among senior secondary school students remains an issue. Some researchers reported male students outperforming female students in chemistry while the reports of other researchers favoured the female students in their achievement in chemistry(Boli, et al., 1985; Levin, Sabar&Libman,1991; Duncan, 1999; Greenfield, 1996; Williams &

Jacobson, 1990; Ekeh, 2003). There were those researchers who stated that sex shows no difference in chemistry achievement among school students. This means there is still a controversy on sex as it affects academic achievement of students.Therefore, this study sought to investigate the effect of the 5E learning cycleand sex on chemistry achievementamong secondary school students in Edo Central Senatorial District.

CHAPTER THREE

RESEARCH METHOD AND PROCEDURE

This chapter deals with research procedures and techniques that were used for the study. They are discussed under the following headings.

- Design of the Study
- Population of the Study
- Sample and Sampling Techniques

- Research Instrument
- Validity of Research Instrument
- Reliability of Research Instrument
- Treatment Procedure
- Method of Data Analysis

Design of the Study

The design of this study wasthe pre-testpost-test control group quasi-experimental research design. The pre-testpost-test control group quasi-experimental research design was considered most appropriate for this study because it involved non-randomization and the use of intact classes. The use of intact classes was to ensure non alteration of regular class periods. The study made use of two groups which were the experimental and control groups. The 5E learning cycle was used to teach the experimental group while the lecture method was used to teach the control group. Table 6 shows the design matrix:

Table 6: The design matrix for Pre-testpost-test control group quasi-experimental research design

Grouping	Pre-test	Treatment	Post-test
Experimental group	O_1	X	O_2
Control group	O_3	x	O_4

O_1 and O_3 represent pre-test (Chemistry achievement test)

O_2 and O_4 represent post-test (Chemistry achievement test)

“X”represents treatment condition;the 5E learning cycle

“x”represents treatment condition: Lecture method

Population of the Study

The population of the study consisted of 5,033 senior secondary school (SS11) chemistry students from 67 Public Senior Secondary Schools in 5 Local Government Areas in Edo Central Senatorial District. The population comprised both male and female chemistry students. Table 7 shows the population of the study.

Table 7: Population of the study (SS 11 Students in Edo Central Senatorial District)

S/N	Local Government Areas	Number of Public Senior Secondary schools	SS 2 STUDENTS		
			Male	Female	Total
1.	Edo Central	13	424	437	**861**
2.	Esan North/East	12	493	634	**1127**
3.	Esan South/East	16	650	491	**1141**
4.	Esan West	16	614	625	**1239**

5.	Igueben	10	314	351	**665**
TOTAL		**67**	**2495**	**2538**	**5033**

Source: *updates of statistical data for public Senior Secondary School 2013/2014 Session by Post Primary Education Board, Benin City.*

Sample and Sampling Techniques

The sample of the study comprised428 Senior Secondary School II students (SS II Students) from ten (10) Public Secondary schools in Edo Central Senatorial District.This sample size comprised all the SS II science students that offered chemistry in the ten secondary schools. The sample was made up of 232 male students and 196 female students.The ten schools were selected from the five Local Government Areas in Edo Central Senatorial District.

The selection of all the ten schools from the five Local Government Areas was through simple random sampling with replacement. That is, the names of all the schools in Each Local Government were written on a piece of paper, folded and dropped in a bowl from which the required number of schools (two schools from each Local Government Area) were drawn one after the other with replacement. Table 8 below shows the sample size of the study-

Table 8: Showing the names of the five (5) Local Government Areas, the ten (10) Secondary schools and the number of SS II male and female students in each class

S/N	Local Government Areas	Name of School	Number of SS II Chemistry Students		
			M	**F**	**Total**
1	Esan Central	Ikekato Senior Secondary School	28	22	**50**
		Ebudin Secondary School	17	12	**29**
2	Esan North East	Arue Senior Secondary School	18	11	**29**
		Senior Secondary School	32	26	**58**
3	Esan South East	Ewatto Grammar School	21	23	**44**
		Ewohimi Secondary School	33	28	**61**
4	Esan West	Ogwa Grammar School	27	22	**49**
		Uhiele Grammar School	18	16	**34**
5	Igueben	Ewossa Senior Sec. School	18	13	**31**
		Ugun Senior Secondary School	20	23	**43**
	Total		**232**	**196**	**428**

Research Instruments

The research instrument wasthe Chemistry Achievement Test and the intervention packages werethe 5E learning cycle instructional plan and the Lecture method lesson plan. The Chemistry Achievement Test is shown in Appendix 1 while the 5E learning cycle instructional plan and the lecture method lesson plan are shown in appendices 2 and 3 respectively.

The Chemistry Achievement Test was constructed by the researcher. It contained 45 multiple–choice objective questions.The Chemistry Achievement Test was constructed to cover the topics, kinetic theory of gases, Boyle's law, Charles' law and General gas law. Each item of CAT carried a unit score, making a total of 45 in all. The intervening packages, that is, the 5E learning cycle instructional plan and the lecture method lesson plan were designed to cover these same topics – kinetic theory of gases, Boyle's law, Charles' law and General gas law. The intervention packages were designed to teach these topics for a period of six weeks.

Validity of the Instrument

The face and content validities of the instrument, Chemistry Achievement Test, were done by 3 experts in the Department of curriculum and integrated science (chemistry) and measurement and evaluation from Delta State University Abraka. The experts were requested to determine if the face and content validities of the instrument were appropriate. They were requested to makenecessary corrections of the instrument to make it suitable for this study. The content validity of the Chemistry Achievement Test was done with a table of specification based on Bloom's Taxonomy of Educational Objectives. The Chemistry Achievement Test was structured to cover all the levels of cognitive domain of students based on Bloom's Taxonomy of Educational Objectives. Table 9shows the table specification for the Chemistry Achievement Test.

Table 9: Table of specification for the Chemistry Achievement Test

CONTENT	KNOWLEDGE	COMPREHENSION	APPLICATION	ANALYSIS	SYNTHESIS	EVALUATION	TOTAL
Kinetic Theory of Gases	2	4	3	2	2	-	**13**
Boyle's Law	3	2	2	2	2	-	**11**
Charles' Law	4	1	2	3	1	-	**11**
General Gas Law	2	2	2	1	3	-	**10**
Total	**11**	**9**	**9**	**8**	**8**	-	**45**
Percentage	**24.4%**	**20%**	**20%**	**17.8%**	**17.8%**	**-**	**100%**

The 5E learning cycle instructional plan and the lecture method lesson plan were prepared by the researcher to be used in teaching the experimental and control groups respectively. These instructional plans were designed to cover the topics- kinetic theory of gases, Boyle's law, Charles' law and General gas law.

Reliability of Research Instrument

In order to assess the reliability of the Chemistry Achievement Test, as the instrument of the study, it was administered to 20 students (that is 10 male and 10 female students) in Opoji Grammar School. These students were not part of the sample size of the study but from the same population. The reliability of the whole instrument was obtained to be 0.82 by applying

Kuder Richardson Formula 20. This high reliability value of 0.82suggested that the instrument was reliable for a study of this nature.

Treatment Procedure

Training of Research Assistants

In training the research assistants, the method developed by Ajajaand Eravwoke(2013) was adapted. The chemistry teachers that taught the experimental group and the control group were trained on the skills of using the 5E learning cycle and the lecture method respectively. This training lastedfor four days and the period foreach training was two hours. Ten chemistry teachers who a hada minimum of 9 years teaching experience at the secondary school level were trained for the purpose of the study. Fiveteachers were trained to teach the experimental groupwhile the other five were trained to teach the control group. On the first day of training the ten chemistry teachers were exposed to the concept ofthe 5E learning cycle and lecture methodand how theycan be used to teach chemistry as a subject. The chemistry teachers were made to understand the differences between these two instructional strategies. Next, the teachers were trained using the 5E learning cycle lesson plan and the lecture method lesson plan developed by the researcher. The 5E learning instructional plan and the lecture method instructional plan specifically define the various stages to go through by both the teachers and the students. The specific roles to be played by both the teachers and the students are well spelt out in the 5E learning cycle and lecture method instructional plans. Having trained the teachers on the third and fourth days, they were required to practise and generate ideas on how to apply the 5E learning cycle and lecture method in the teaching of the selected topics, kinetic theory of gases, Boyle's law, Charles' law and General gas law. The researcher ensured that the ten chemistry teachers were well trained for the purpose of the study before the training came to an end.

Before treatment commenced proper, the researcher provided the trained teachers withthe 5E learning cycle instructional plan and the lecture method instructionalplans that have been prepared. The purpose of this was to ensure that the trained chemistry teachers follow a uniform lesson plan in all the classes. The lesson notes for the 5E learning cycle specified both the teachers' and students' activities at the Engagement, Exploration, Explanation, Elaboration and Evaluation stages of the learning cycle (see Appendix 2). The lesson notes for the lecture method also specified both the teachers' activities and students' activities (see Appendix 3).

Treatment Proper

Before the commencement of treatment, both the experimental and control groups were pre-tested. This was done to determine the equivalence of the groups before treatment. This involved the use of 45-item Chemistry Achievement Test.

On treatment, for the control group, each and of contents in the six-week instructional unit for chemistry was presented to the students using the lecture method while in the experimental group each content in the six-week instructional unit was presented to the students using the 5E learning cycleby applying Bybee's (2009) format at the various stages (see Appendix 2).

At the end of the six weeks of instruction, both experimental and control groups were given a post-test, that is, the chemistry achievement test. The pre-test and post-test questions are the same but were re-arranged in numbering before post-test.

Method of data collection involved the use of the Chemistry Achievement Test. The Chemistry Achievement Test was administered to theseparate groups (Experimental and Control groups) as pre-test and post-test.The students' answer scripts and the instrument were retrieved immediately from the students by the research assistants at the end of the tests.

Method of Data Analysis

The scoring of students' response was on the minimum of 0 and maximum of 45 marks. Mean, standard deviation, paired samples t-test, independent samples t-test and a Two-way Analysis of Covariance(ANCOVA) were used to analyse the data that were collected. All the research questions were answered using mean and standard deviation. All the hypotheses were tested at the 0.05 level of significance using paired samples t-test (for hypothesis 1), independent samples t-test (for hypotheses 2, 3 and 4) and a Two-way Analysis of Covariance (ANCOVA) for hypothesis 5.

CHAPTER FOUR

PRESENTATION OF RESULTS AND DISCUSSION

This chapter deals with the presentation of results and discussion of findings. The results obtained are hereby presented as follows:

Answering of Research Questions

Research Question One: Is there any difference in the pre-test and post-test scores of students taught with the 5E learning cycle method?

To answer research question 1, table 10 was provided.

Table 10: The difference in the pre-test and post-test scores of students taught with the 5E learning cycle method

Variables	N	Mean	Std. Deviation
Pre-Test the 5E learning cycle	229	28.54	7.57
Post-Test the 5E learning cycle	229	42.43	3.79

Table 10 shows the difference in the pre-test and post-test scores of students taught with the 5E learning cycle method. From the table, students pre-test mean score was 28.54 while the post-test mean scores was 42.43, showing a difference of 13.89. This is an indication that there is a difference in the pre-test and post-test scores of students taught with the 5E learning cycle method.

Ho_1: There is no significant difference in the pre-test and post-test scores of students taught with the 5E learning cycle method.

Hypothesis one was tested with the results in Table 11.

Table 11: Analysis of the difference in the pre-test and post-test score of students taught with the 5E learning cycle method

Variables	N	Mean	SD	t	P	Decision
Pre-Test	229	28.54	7.57	24.43	.000	Significant
Post-Test	229	42.43	3.79			

Table 11 shows a paired-samples t-test, which was conducted to examine the difference in the pre-test and post-test scores of students taught with the 5E learning cycle method. Preliminary analysis conducted to ensure that the assumptions of normality and homogeneity of variance are not violated showed no violations (see appendix v and vi). From the result, the p-value of 0.000 was less than 0.05 level of significance ($t = 24.43$, $p<0.05$).The null hypotheses is, therefore, rejected. This means that there is a significant difference in the pre-test and post-test scores of students taught with the 5E learning cycle method, in favour of post-test group.

Research Question Two: Is there any difference in chemistry achievement between students taught with the 5E learning cycle and those taught with lecture method?

Table 12 is used to answer research question 2.

Table 12: Comparison of the chemistry achievement of students taught with the 5E learning cycleand those taught with lecture method

Variables	N	Mean	Std. Deviation
the 5E learning cycle	229	42.43	3.79

Lecture Method	199	32.55	4.40

Table 12 shows chemistry mean scores between students taught with the 5E learning cycle and those taught with lecture method. The table shows that students taught with the 5E learning cycleachieved higher in chemistry test than those taught with the lecture method,with a difference mean score of 9.88. This shows that there is a difference in chemistry achievement between students taught with the 5E learning cycle and those taught with lecture method in favour of those taught with 5E learning cycle.

Ho_2: There is no significant difference in chemistry achievement between students taught with the 5E learning cycle and those taught with lecture method.

Hypothesis Two was tested with the results in Table 13.

Table 13: t-test summary comparing chemistry achievement between students taught with the 5E learning cycle and those taught with lecture method

Variables	**N**	**Mean**	**SD**	**T**	**P**	**Decision**
the 5E learning cycle Method	229	42.43	3.79	25.11	.000	Significant
Lecture Method	199	32.55	4.40			

The result in table 13 showed an independent-samples t-test, which was conducted to compare the chemistry achievement of students taught with the 5E learning cycle and those taught with lecture method. Preliminary analysis conducted to ensure that the assumptions of normality and homogeneity of variance are not violated, showed no violations (see appendix v and vi). Result shows that there is a significant difference in chemistry achievement between students taught with the 5E learning cycle and those taught with lecture method ($t = 25.11$, $p<0.05$).Hence, the null hypothesis was rejected meaning there is a significant difference in chemistry achievement between students taught with the 5E learning cycle and those taught with lecture method, in favour of those taught with 5E learning cycle.

Research Question Three: Is there any difference in chemistry achievement between male and female students taught with the 5E learning cycle?

Table 14 provides answer to research question 3:

Table 14: Comparing achievement in chemistry between male and female students taught with the 5E learning cycle

Gender	N	Mean	Std. Deviation
Male	129	42.08	3.70
Female	100	42.88	3.88

Table 14 compares male and female students'chemistry mean scores when taughtwith the 5E learning cycle. The results in the table show that both male and female students taught with the 5E learning cycle have almost the same mean scores in chemistry achievement test with just a difference of 0.8. This shows that there is not much difference in chemistry achievement between male and female students taught with the 5E learning cycle.

Ho_3: There is no significant difference in chemistry achievement between male and female students taught with the 5E learning cycle

Hypothesis Three (Ho_3) was tested and the results are presented in Table 15

Table 15: t-test summary comparing chemistry achievement between male and female students taught with the 5E learning cycle (See Appendix VII)

Variables	**N**	**Mean**	**SD**	**t**	**P**	**Decision**
Male	129	42.08	3.69	1.60	0.11	Not Significant
Female	100	42.88	3.88			

An independent-samples t-test was conducted to compare the difference in the chemistry achievement of male and female students taught with the 5E learning cycle. Again, preliminary analysis conducted to ensure that the assumptions of normality and homogeneity of variance are not violated showed no violations (see appendix v and vi). Result showed that the p-value of 0.11 is more than 0.05 level of significance ($t = 1.60$, $p>0.05$).Hence, the null hypothesis is retained. This means that that there is no significant difference in chemistry achievement between male and female students taught with the 5E learning cycle.

Research Question Four: Is there any difference in chemistry achievement of students taught with the 5E learning cycle based on their age

To answer research question 4, the table below was provided.

Table 16: Difference in chemistry achievement of students taught with the 5E learning cycle based on their age

Age	N	Mean	Std. Deviation
10-15	127	42.24	3.89
16-20	102	42.67	3.67

Table 16 shows the comparison between the mean score of students taught with the 5E learning cycle based on their age. From the table those in the age range of 10-15 years of age scored 42.24 while those in the age range of 16-20 years of age scored 42.67 with a slight difference of 0.43. This means that there is no difference in the chemistry achievement of students taught with the 5E learning cycle based on their age.

Ho_4: There is no significant difference in chemistry achievement of students taught with the 5E learning cycle based on their age.

Table 17: t-test summary comparing chemistry achievement of students taught with the 5E learning cycle based on their age

Variables	**N**	**Mean**	**SD**	**T**	**p**	**Decision**
Age 10-15	127	42.24	3.89	0.85	0.39	Not Significant
Age 16-20	102	42.67	3.67			

From Table 17, an independent-samples t-test was conducted to compare the difference in the chemistry achievement of students taught with the 5E learning cycle based on their age. Also, preliminary analysis conducted to ensure that the assumptions of normality and homogeneity of variance are not violated showed no violations (see appendix v and vi). From the result, the p-value of 0.39 is higher than 0.05 level of significant ($t = 0.85$, $p>0.05$). The null hypothesis is therefore retained. This means that there is no significant difference in chemistry achievement of students taught with the 5E learning cycle based on their age.

Research Question Five: Is there any interaction effect between method and sex on chemistry achievement?

To answer research question 5, Table 18 was provided.

Table 18: Table showing the interaction effect betweenmethod and sex on chemistry achievement

Group	**Gender**	**N**	**Mean**	**Std. Deviation**
Experimental	Male	129	42.08	3.69
	Female	100	42.88	3.88

	Total	229	42.43	3.79
Control	Male	103	32.34	4.39
	Female	96	32.51	4.19
	Total	199	32.42	4.28
Total	Male	232	37.75	6.29
	Female	196	37.80	6.57
	Total	428	37.78	6.41

Table 18 shows the interaction effect betweenmethod and sex on chemistry achievement. From the table, after controlling for their pre-test mean scores, the total mean score for male students is 37.75 while that of the females is 37.80 with a difference of 0.5, an indication that there is no interaction effect betweenmethod and sex on chemistry achievement.

Ho_5: There is no significant interaction effect between method and sex on chemistry achievement

Hypothesis five was tested with the results in Table 19

Table 19: ANCOVA summary table of interaction effect between method and sex on post achievement

Tests of Between-Subjects Effects

Dependent Variable: Post-Test Score

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	10719.019[a]	4	2679.755	165.638	.000	.610
Intercept	41620.733	1	41620.733	2572.617	.000	.859
Pre_Test	21.433	1	21.433	1.325	.250	.003
Gender	25.428	1	25.428	1.572	.211	.004
Group	10676.821	1	10676.821	659.944	.000	.609
Gender * Group	**10.873**	**1**	**10.873**	**.672**	**.413**	**.002**
Error	6843.449	423	16.178			
Total	628320.000	428				
Corrected Total	17562.467	427				

a. R Squared = .610 (Adjusted R Squared = .607)

Table 19showsa Two-Way Analysis of Covariance (ANCOVA), which was conducted to assess the interaction effect between method and sex on chemistry achievement. Pre-test scores of the students were used as the covariance to control for individual differences. Preliminary checks were conducted to ensure that there was no violation of the assumptions of normality, linearity, homogeneity of variances, homogeneity of regression slopes, and reliable measurement of the covariate (see appendix v,vi and vii). The result shows that there is no interaction effect between method and sex on chemistry achievement ($F = 0.67$, $p > 0.05$). Since the p-value is greater than 0.05, the null hypothesis is hereby retained. This means that there is no interaction effect between method and sex on chemistry achievement.

Discussion

The focus of the study was to examine the effects of the 5E learning cycle and sex on chemistry achievement among secondary school students. The study examined chemistry achievement between students taught with the 5E learning cycle and those taught with the lecture method. The study also examined chemistry achievement between male and female students and students in the age range of 10-15 years and those in the age range of 16-20.

The first finding shows that there is a significant difference in the pre-test and post-test scores of students taught with the 5E learning cycle method. This result inTable 12 suggests that the difference between the pre-test and post-test scores of the students is not due to chance but due to the treatment.In line with the findings of Ajaja and Eravwoke (2012). In their study, they examined the effects of the 5E learning cycle on students' achievement in biology and chemistry. They found a significant difference in the pre-test and post-test scores of students taught with the 5E learning cycle method of teaching. This finding is also in line with that of Lord (1999), who compared the effects of the 5E learning cycle instruction with the traditional instruction in environmental chemistry and discovered that while the control group students found the lessons boring, the experimental group students found them interesting and had a lot of fun.

The second finding shows a significant difference in chemistry achievement between students taught with the 5E learning cycle and those taught with lecture method. This finding agrees with that of Yalcin (2006) who stated that the 5E learning cycle makes science knowledge long-lasting in the mind of the learner as compared with the lecture method. The study also supports the finding of Ajaja and Eravwoke (2012) that there is a significant difference in post-achievement test scores between the students in 5E learning cycle group and those in lecture group. The reason for the difference in the chemistry achievement of students taught with 5E learning cycle method and lecture may be becausethe 5E learning cycle makes students actively involved in the teaching learning process rather than being passive; it also makes learning more interesting.

The third finding shows that there is no significant difference in chemistry achievement between male and female students taught with the 5E learning cycle. However, this finding is at variance with the findings of Husen (1999), who found that even if learning opportunities and teaching strategies would be equally effective in chemistry instruction for every boy or girl in class with a formal test given at the end of a certain curricular sequence would still yield marked differences between boys, between girls and between boys and girls. But the finding agrees with the finding of Ajaja and Eravwoke (2012), which showed a non-significant difference in the post-achievement test scores between male and female students in the 5E learning cycle classroom. The reason for the non-significant difference in the chemistry achievement between male and female students taught with 5E learning may be because, the students, irrespective of sex, benefited from the 5E learning cycle. Ajaja and Eravwoke (2012:259) opined that “what matters most in the 5E learning cycle is role expectation and responsibilities of both teachers and students at every stage of the model”. According to them, “the success of a learning cycle activity depends on proper guidance of students by the teacher specifying role expectation and responsibilities and modelling them where necessary at every stage of the model”.

The fourth finding shows that there is no significant difference in chemistry achievement of students taught with the 5E learning cycle based on their age. This finding is consistent with the finding of Qarareh (2012), that there is no statistically significant differences in the achievement of students in different age groups. This finding suggest that when the 5E learning cycleis applied into teaching and learning, students of all age groups will benefit equally.

Finally, the fifth finding showed a non-interaction effect between method and sex on chemistry achievement. This finding is consistent with the finding of Ajaja and Eravwoke (2012), who conducted a study on the effects of the 5E learning cycle on students' achievement in biology and chemistry and found a non-significant interaction effect betweenmethod and sex on achievement. The reason for the non-interaction effect could be attributed to the fact that the teachers that taught the students using the 5E learning cycle method, taught them very well that all the students, irrespective of gender, understood the subject matter.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter is organized under the following sub-headings-

- Summary of the Research
- Major Findings
- Conclusion
- Contribution to Knowledge
- Recommendations
- Suggestions for Further Studies

Summary of the Research

This study investigated the effects of the 5E learning cycle and sex on students' achievement in chemistry in Edo Central Senatorial District. Five research questions were raised and five hypotheses formulated for the study. The research instrument was Chemistry achievement test with intervention package of the 5E learning cycle and lecture method lesson plans. The design of the study was the pre-test post-test control group quasi-experimental design. The population of the study was 5,033male and female students and a sample size of 428 male and female students from Senior Secondary School II students (SS II Students). Sampling techniques involved the use of balloting, withdrawal with replacement. Four (4) teachers were trained as research assistants. Two research assistants were trained on how to use the 5E learning cycle and the other two were trained on how to use lecture method. Lesson noteson the 5E learning cycle and lecture method were provided. These lesson notes provided step by step procedure that the research assistants followed when teaching the sampled students. The researcher exposed the research assistants to the topics (that is, kinetic theory of gases, Boyle's law, Charles' law and General gas law) in chemistry that were covered. The training of research assistants lasted four days. The treatment commenced a week after the training of the research assistants. During the treatment phase, research assistants were divided into two groups: the experimental group and the control group.Data collected were analysed using mean, standard deviation, paired samples t-test and independent samples t-test and a two-way Analysis of Covariance (ANCOVA).

Findings

The major findings of the study are:

1. There wasa significant difference between the pre-test and post-test scores of students taught using the 5E learning cycle.
2. There wasa significant difference in chemistry achievement between students taught with the 5E learning cycle and those taught with lecture method.

3. There was no significant difference inchemistry achievement between male and female students taught with the 5E learning cycle.
4. There was no significant difference inchemistry achievements of students of varying ages taught with the 5E learning cycle.
5. There was no significant interaction effect between method and sex on chemistry achievement.

Conclusion

Based on the findings of this study, the following conclusion is drawn:

i Since the result of the study showed that there was an improvement in the chemistry achievement of the students in their post-test as against their pre-test result, it can therefore be concluded that the use of the 5E learning cyclehas an effect on chemistry achievement among school students

ii Since there was a significant difference between chemistry achievement between students taught with the 5E learning cycleand those taught with lecture method, it can therefore be concluded that the 5E learning cycle is more effective than lecture in the teaching of chemistry.

iii Since the results of the study showed that male and female students taught with the 5E learning cycle had almost the same achievement in chemistry, it is concluded that that learning cycle instructional strategy is not sex biased.

iv Since the results of the study showed no significant difference between chemistry achievement of students of varying ages taught with the 5E learning cycle, it can therefore be concluded that the use of the 5E learning cycle will be suitable for teaching chemistry students irrespective of their ages.

v Since the results of the study revealed that teaching method does not interact with sex to have effect on chemistry achievement among school students, it is therefore concluded that neither sex nor method combine to influence students achievement when the 5E learning cycle is used for teaching.

Contribution to Knowledge

The study has contributed to knowledge in the following ways:

- The study established that the 5E learning cycleis a better teaching method than the conventional lecture method for teaching chemistry.
- The study establishedthat the use of the 5E learning cyclein teaching of chemistry is not gender sensitive and thus suitable for both sex of students.
- The study establishedthat the 5E learning cycleis not secondary school age restricted and thus suitable for teaching all classes.

Recommendations

From the findings and the conclusion, the following recommendations are given to improve the teaching and learning of chemistry:

i Teachers should adopt the use of the 5E learning cycle in the teaching and learning of chemistry.

ii Teachers should attend on a regular basis in-service training workshops to keep them abreast of new and effective chemistry teaching methods like the 5E learning cycle.

Suggestions for Further Studies

The researcher suggests the following areas for further research-

1. This study was restricted to only Edo Central Senatorial District. It is, therefore, suggested that similar studies be carried out in the other Senatorial Districts of the State.
2. A similar study should be carried out in other disciplines such as mathematics, biology and physics.

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APPENDIX I

(TEACHER-MADE TEST)

DEPARTMENT OF CURRICULUM AND INTEGRATED SCIENCE,

DELTA STATE UNIVERSITY, ABRAKA.

CHEMISTRY ACHIEVEMENT TEST (CAT)

(Adapted from past years promotion examination questions on chemistry conducted by Edo State Ministry of Education for senior secondary school (SS II) students)

Class: SSS II **Time:**40minutes

Instructions:

Each of the questions contain four options lettered A – D. Choose the option that best answer each of the question and cycle it as in (A)

A. number of gas molecules present C. Pressure

D. Temperature D. molar mass of the gas

1 The volume that is occupied by an ideal gas is not affected by changes in the

2 Which equation represents Boyle's law?

A. $PV = k$ C. $\frac{P}{k} = V$

B. $VT = k$ D. $\frac{V}{k} = T$

3 If a sealed 1 L jar is cooled, what happens to the gas molecules?

A. They move more slowly.

B. They collide more often with the walls of the jar.

C. Their vibration increases.

D. They move farther apart.

4 Which statement correctly describes what happens to the mass of a fixed quantity of gas?

A. The mass increases when the volume increases, at constant temperature.

B. The mass decreases when the absolute temperature decreases, at constant pressure.

C. The mass does not change at any temperature or pressure.

D. The mass decreases as the density increases.

5 Which statement best accounts for the fact that gases can be easily compressed?

A. Molecules occupy space.

B. The collisions of molecules are elastic.

C. Molecules of gases are in constant motion.

D. Molecules of gases are relatively far from each other

6 A sample of gas has a volume of 40 mL at 5.0 atm. The gas is allowed to expand until its volume is 100 mL. Calculate the new pressure.

A. 0.25 atm C. 2.0 atm

0.40 atm D. 3.0 atm

7. A gas is stored at 26 ^{o}C in a cylinder and pressure is applied to compress the gas. If the pressure is doubled, the new volume of the gas will be

A. Doubled		C. Tripled

B. Halved		D. Quadrupled

8. A sample of nitrogen gas has a volume of 0.20 L at 1.0 atm pressure and 0 ^{o}C. At the same pressure, what is the volume of gas at 270 ^{o}C?

A. 0.16 L		C. 0.85 L

B. 0.40 L		D. 0.96 L

9. A sample of $CO_2(g)$ has a volume of 2L at pressure P and temperature T. If the pressure becomes triple the original value, at the same absolute temperature, the volume of CO_2 will be

A. $\frac{3}{2}$ L		C. $\frac{2}{3}$ L

B. 6 L		D. 2 L

10. The number of moles per litre of an ideal gas, in terms of pressure, P, gas constant, R, and temperature, T, is

A. PT/R		C. RT/P

B. P/RT		D. PRT

11. N_2, O_2, CH_4 and CO_2, all exist as real gases. None of them behave like an ideal gas at high pressure and low temperature. They deviate from ideal gas nature because their molecules

A. are colourless C. contain covalent bond

B. attract each other D. show Brownian movement

12. Which of the following is a wrong statement about the gas laws?

A. Breathing illustrates Boyle's law.

B. Charles' law illustrates that the volume of gas expands when temperature becomes higher.

C. Avogadro's law illustrates that the volume of gas is proportional to its mole number or say its quantity or amount.

D. Gay-Lussac's law illustrates that the pressure of gas is proportion to its temperature.

13. A gas sample of argon, maintained at constant temperature, occupies a volume of 500 L at 4.00 atm. What is the new volume if the pressure were charged to 8 atm?

A. 500 L B.250 L C. 125 L D. 62.5 L

14. What is the resulting temperature of the gas if 200 mL of a gas sample at 27°C expands to 500 mL?

A. 750 K B. 477°C C. 890.6 °F D. All of the above

15. A gas under 25 atm pressure occupies 35.0 L at 127°C. What is the volume of the gas under standard conditions (1 atm, 0°C)?

A. 0 L B. 597.2 L C. 1880.9 L D. 3000 L

16. A sample of gas has a volume of 0.600 L at a temperature of 30 °C and a pressure of 0.8 atm. What is the number of moles in this sample?

A. 0.2 B. 0.02 C. 14.4 D. 145.4

17. A gas under 25 atm pressure occupies 35.0 L at 127°C. What is the volume of the gas under standard conditions (1 atm, 0°C)?

A. 0 L B. 597.2 L C. 1880.9 L D. 3000 L

18. Which of the following statements is <u>wrong</u> in consideration of molecular packing among three states of matter?

A. Gas molecules are packed loosely.

B.Solid molecules are packed as closely together as possible.

C. Liquid molecules are in-between the gas and solid molecules.

D. All of the above statements are correct.

19. Which of the following definition is wrong?

A. The temperature at which a liquid boils at 1 atm is called normal boiling point.

B. The temperature at which a liquid freezes is called freezing point.

C. The melting point and freezing point for a substance are actually the same.

D. None of the above is wrong.

20. A gas is stored at 26 ^{o}C in a cylinder and pressure is applied to compress the gas. If the pressure is doubled, the new volume of the gas will be

A. Doubled

B. Halved

C. tripled

D. quadrupled

21. Air molecules confined in a closed volume undergo more collisions when that volume:

A. Decreases

B. Increases

C. Is chilled by at least 10 degrees Celsius

D. Vibrates

22. Which is the best way to characterize an inverse relationship?

A. As one quantity decreases, the other quantity decreases at the same rate.

B. As one quantity increases, the other quantity decreases proportionally.

C. As one quantity increases, the other quantity undergoes a random change.

D. None of the above

23. The inverse of 4.0 is equal to:

A. 40.0

B. 1.0

C. 0.25

D. 4

24. The relationship between the volume of a gas and its pressure can be seen in which example?

A. The adhesive used to glue labels onto containers

B. A suction cup used to attach something to a wall

C. An empty balloon waiting to be inflated with helium gas

D. None of the above

25. Which statement isfalse?

A. The density of a gas is constant as long as its temperature remains constant.

B. Gases can be expanded without limit.

C. Gases diffuse into each other and mix almost immediately when put into the same container.

D. The molecular weight of a gaseous compound is a non-variable quantity.

26. Under conditions of fixed temperature and amount of gas, Boyle's law requires that

I. $P_1V_1 = P_2V_2$

II. PV = constant

III. $P_1/P_2 = V_2/V_1$

A. I only C. III only

B. II only D. I, II, and III

27. A real gas most closely approaches the behaviour of an ideal gas under conditions of:

A. STP C. low P and T

B. low P and high T D. high P and T

28. For a gas, which pair of variables are inversely proportional to each other (if all other conditions remain constant)?

A. P, T B. P, V C. V, T D. n, V

29. A gas sample of argon, maintained at constant temperature, occupies a volume of 500 L at 4.00 atm. What is the new volume if the pressure were charged to 8 atm?

A. 500 L B.250 L C. 125 L D. 62.5 L

30. What is the resulting temperature of the gas if 200 mL of a gas sample at 27^{o}C expands to 500 mL?

A. 750 K B. 477^{o}C C. 890.6 ^{o}F D. All of the above

31. A gas under 25 atm pressure occupies 35.0 L at 127°C. What is the volume of the gas under standard conditions (1 atm, 0°C)?

A. 0 L B. 597.2 L C. 1880.9 L D. 3000 L

32. Which of the following statements is <u>wrong</u> in consideration of molecular packing among three states of matter?

A. Gas molecules are packed loosely.

B.Solid molecules are packed as closely together as possible.

C. Liquid molecules are in-between the gas and solid molecules.

D. All of the above statements are correct.

33. If the pressure on a gas is constant and the temperature is decreased, the volume will

A. Decrease B. Increase C. Remain the sameD. None of the above

34. Charle's law states that

A. when the pressure of a gas is constant, its volume is directly proportional to its temperature.

B. when the pressure of a gas is constant, its volume is inversely proportional to its temperature

C. when the temperature of a gas is constant, its volume is directly proportional to its temperature

D. when the temperature of a gas is constant, its volume is inversely proportional to its temperature

35. If the pressure on a gas is constant and the volume is decreased the temperature will

A. Decrease B. Increase C. Remain the sameD. None of the above

36. Which of the following is a correct statement of Charle's Law?

A. V/T = constant B. PV = constant

C. TV = constant D. V/P = constant

37. Which of the following pairs refer to direct relationship?

A. Temperature and Volume B. Pressure and Volume

C. Temperature and Pressure C. Volume and Pressure

38. Which of the following statements is not true of the kinetic theory of gases?

A. The pressure of a gas depends on the average value of the square of the speeds of themolecules.

B. The temperature of a gas is proportional to the average kinetic energy of the molecules.

C. For a gas of diatomic molecules, the average translational kinetic energy per moleculeIs 5/2 kT.

D. Each degree of freedom is associated with an amount of energy given by ½ kT.

39. PV = constant supports

A. Charle's law B. Boyle's law C. Graham's lawD. Avagadro's law

40. Kelving temperature can be converted into Celsius temperature by using

A. $^{o}C = K - 273$B. $K = {}^{o}C - 273$C. $^{o}C = K + 273$ D. $K = {}^{o}C - 273$

41. In order to solve problems using Charle's Law the temperature must be measured in:

A. Fahrenheit B. CelsiusC.Kelvin D.Kitzmann

42. What happens to the temperature of a gas when it is expanded quickly?

A. The temperature increases.

B. The temperature does not change.

C. The temperature decreases.

D. None of the above.

43. As the temperature of the gas in a balloon decreases _____.

A. the volume increase.

B. the average kinetic energy of the gas decreases

C. the pressure increases

D. All of the above

44. Which of the following is one of the gas laws?

A. Newton's law of motion B. Charle's law

C. Law of gravity C. Law of multiple proportion

45. What happens to the behaviour of gases when pressure is increased?

A. All gases approach ideal gas behaviour.

B. All gases deviate from the ideal gas behaviour.

C. The gases simply turn into real gases.

D. The gases become highly soluble in water.

APPENDIX II

The 5E learning cycle LESSON ONE

Topic: Kinetic Theory of Gases

Essential Standard: To understand the theory of gases and the interaction between gases

Clarifying Objective: By the end of the lesson the students should be able to do the following -

i. State the theory of gases
ii. List three states of matter
iii. Describe pressure exerted by gases

Materials/Resources: New Senior Secondary School Chemistry by Ababio, Charts, Chalkboard and Chalk

Engagement: The teacher carries out simple experiments by melting an ice block into water. The teacher heats ice solid until the particles acquire more kinetic energy and vibrate violently. The Teacher continues to heat the water until it starts boiling. The molecules of the boiling water exerts a pressure on the walls their container.

The teacher gives students time to observe the simple experiment and asks them the following questions to engage them.

- Why do the molecules of boiling water vibrate faster than those of melting ice?
- Observing the experiments what are the possible behaviour of gases? This leads student to state the kinetic theory of gases
- Teacher asks students to note the pressure the molecules of boiling water exert on the walls of the container.

Exploration: The teacher organizes students into groups of two to three members and assign one third of the groups to work together. The teacher asks students to get a closed container with liquid inside it. The teacher asks students to heat it gently and the teacher asks students to do the following

- Observe the movement of the particles of the liquid in the container
- Students are allowed to think freely in order to provide an answer to why the molecules of the liquid in the container move randomly.
- Students are to record their observations and ideas.

Explanation: Students explain their observations from the Exploration phase and participate in a teacher-led discussion as a formative assessment of student understanding. This portion of the lesson also provides an opportunity for the teacher to give a detailed explanation on new concepts. Students are expected to do the following-

- Teacher asks students to explain their answers to the questions in phase one and two to another.
- Students are given time to discuss their answers with one another.
- Students are also given time to question one another's explanations.

Elaboration: Teacherbegins with a think-pair-share activity by asking the students to do the following-

- Teacher asks students, do all gases exert pressure? Is Kinetic Theory of Gases applicable to all gases?
- Why do you think that a solid melts when heated?
- Teacher asks students to relate with each other by sharing their observations and ideas gotten from the lesson.
- Teacher asks students to apply the knowledge they have acquired to explain why gases escape when a bottle of coke is opened.

Evaluation: In order to determine the extent to which the objectives of the lesson have be achieved, the teacher asks students to provide detailed answers to the following questions:

- What happens to the pressure exerted by molecules of boiling water when you increase the temperature of the boiling water?
- What happens to ice when you subject it to an increased temperature?
- State the Kinetic Theory of matter

5E LEARNING CYCLE LESSON TWO

Topic: Charles and Boyle's Laws

Essential Standard: To understand Charles and Boyle's laws of gases.

Clarifying Objective: By the end of the lesson the students should be able to:-

i. State Charles' Law
ii. Express Charles' Law Mathematically

iii. Do simple calculations involving Charles' Law

iv. State Boyle's Law

v. Express Boyle's Law Mathematically

vi. Do simple calculations involving Boyle's Law

Materials/Resources: New Senior Secondary School Chemistry by Ababio, Charts, Chalkboard and Chalk

Engagement: The teacher carries out simple experiments to demonstrate Boyle's and Charles Laws by reducing the temperature and pressure of a fixed mass of a gas in a rubber tubing attached to a burette. The rubber tube is filled with a fixed mass of mercury and the students are allowed to observe the rise and fall of the volume of that gas as its temperature and pressure vary. Teacher asks students the following questions-

- Why does the volume of the fixed mass of gas reduce as the temperature reduces?
- Why does the volume of the fixed mass of gas increase as the pressure increases?

Exploration: The teacher organizes students into groups of two to three members and assign one third of the groups to work together. The teacher asks students to establish a relationship between Boyle's law and Charles' law. Teacher also asks students to do the following-

- Teacher asks students to differentiate between general gas equation and an ideal gas equation.
- Teacher asks students to derive the general gas equation.
- Teacher asks students to do simple calculations involving general gas equation. For example, under a pressure of $3000Nm^{-2}$, a gas has a volume of $250cm^3$. What will its volume be if the pressure is changed to 100 mmHg at the same temperature? (760mmHg = 101325 Nm^{-2}).

Explanation: Students explain their observations from the Exploration phase and participate in a teacher-led discussion as a formative assessment of student understanding. This portion of the lesson also provides an opportunity for the teacher to give a detailed explanation on new concepts. Students are expected to do the following-

- Teacher asks students to explain their answers to the questions in phase one and two to another.
- Students are given time to discuss their answers with one another.
- Students are also given time to question one another's explanations.

- The teacher at this stage introduces new concepts, phrases, or sentences to label what the students have already found out – and guide them to arrive at correct conclusions. Teacher then goes ahead, to explain the general gas law and it's mathematical expression.

Elaboration: The teacher gives students new information that extends what they have been learning in the previous phases. Teacher asks students, do all gases obey the general gas law? Is Kinetic Theory of Gases applicable to all gases?

Teacher asks students to apply the general gas equation to solve simple and complex problems involving gas pressure, volume and temperature

Evaluation: In order to determine the extent to which the objectives of the lesson have be achieved, the teacher asks students to provide detail answers to the following questions:

- State General Gas Law
- Derive General Gas Equation
- 375cm^3 of a gas has a pressure of 770mmHg. Find its volume if the pressure is reduced to 750mmHg.

The 5E learning cycle LESSON THREE

Topic: General Gas Law

Essential Standard: To understand general gas laws.

Clarifying Objective: By the end of the lesson the students should be able to:-

i. State General Gas Law
ii. Derive General Gas Equation
iii. Solve simple calculations involving General Gas Equation

Materials/Resources: New Senior Secondary School Chemistry by Ababio, Charts, Chalkboard and Chalk

Engagement: The teacher states the mathematical expressions for both Boyle and Charlee's laws. Teacher combines these two equations and establishes the General gas laws mathematically. The teacher engages students by asking them the following questions

- What is the result of combining Charles and Boyle's Laws?
- Teacher asks students to state the general gas

Exploration: The teacher organizes students into groups of two to three members and assign one third of the groups to work together. The teacher asks students to establish a relationship between the volume and pressure of a fixed mass of gas. Teacher also asks students to establish a relationship between the temperature and volume of a fixed mass of gas. Teacher also asks students to do the following-

- Teacher asks students to demonstrate an experiment that explains the relationship between gas pressure and volume. This experiment explains Boyle's Law.
- Teacher also asks student to demonstrate an experiment that describes the relationship between gas temperature and volume. This experiment explains Charles Law.

Students are to record their observations and ideas during these experiments

Explanation: Students explain their observations from the Exploration phase and participate in a teacher-led discussion as a formative assessment of student understanding. This portion of the lesson also provides an opportunity for the teacher to give a detailed explanation on new concepts. Students are expected to do the following-

- Teacher asks students to explain their observations in phase one and two to another.

- Students are given time to discuss their answers with one another.
- Students are also given time to question one another's explanations.

The teacher at this stage introduces new concepts, phrases, or sentences to label what the students have already discovered – and guide them to arrive at correct conclusions. Teacher then goes ahead, to explain Charles Law and Boyle's Law to the students and do simple calculations involving the gas laws

Elaboration: The teacher gives students new information that extends what they have been learning in the previous phases. Teacher provides students with some mathematical problems to solve. This requires students to apply the mathematical expressions for Charles and Boyle's Laws to solve simple problems. For example, At 17^oC, a sample of hydrogen gas occupies $125cm^3$. What will the volume be at 100^oC, if the pressure remains constant? (Answer: The new volume will be $161cm^3$)

Evaluation: The teacher asks students the following questions in order to evaluate the lesson -

- State Charles and Boyle's Laws
- Express Charles and Boyle's Laws mathematically

- $375cm^3$ of a gas has a pressure of 770mmHg. Find its volume if the pressure is reduced to 750mmHg.

APPENDIX III

LECTURE METHOD LESSON NOTES 1

TOPIC: Kinetic Theory of Gases

CLASS: SSS II

TIME: 2 PERIODS OF 40 MINUTES EACH

SEX: MIXED

AGE: 15^+

INSTRUCTIONAL MATERIALS: New Senior Secondary School Chemistry by Ababio, Charts, Whiteboard and Black ink Marker.

BEHAVIOURAL OBJECTIVES: By the end of the lesson the students should be able to:-

i. State kinetic theory of gases

ii. List Three states of matter

iii. Describe pressure exerted by gases

ENTRY BEHAVIOUR: Students can state the types of matter.

LESSON DEVELOPMENT

STEP 1: The teacher gains students' attention by asking questions such as what is kinetic theory of gases?

STEP 2: The teacher makes students aware of objectives of the lesson.

STEP 3: The teacher introduces the lesson by writing the topic on the whiteboard.

STEP 4: The teacher develops the topic of the lesson as follow -

KINETIC THEORY OF GASES

Kinetic theory of gases postulates the following;

1. A gas consists of a collection of small particles traveling in straight-line motion and obeying Newton's Laws.

2. The molecules in a gas occupy no volume (that is, they are points).
3. Collisions between molecules are perfectly elastic (that is, no energy is gained or lost during the collision).
4. There are no attractive or repulsive forces between the molecules.
5. The average kinetic energy of a molecule is $3kT/2$. (T is the absolute temperature and k is the Boltzmann constant.)

STATES OF MATTER

Matter is anything that has mass and occupies space. Matter exists in three states which include solid state, liquid state and gaseous state. The fundamental difference between these three states of matter is the degree of movement of their particles.

PRESSURE EXERTED BY GASES

Consider the molecules of a gas moving at random in a container. The molecules are continually colliding with each other and with the walls of the container. It is assumed that all collisions are elastic. When a molecule collides with the wall, a change of momentum occurs. The change in momentum is caused by the force exerted by the wall on the molecule. The molecule exerts an equal but opposite force on the wall. The pressure exerted by the gas is due to the sum of all these collision forces. If the temperature of the gas is increased, the average kinetic energy of its molecules increases. Therefore, the molecules hit the wall "harder" and also more frequently. The total force due to the collisions is greater. Therefore the pressure increases. This is why the pressure exerted by a gas increases as the temperature increases

STEP 5: Teacher provides a summary of the lesson to enhance students learning process.

STEP 6: The teacher evaluates the students to determine the extent to which the objectives of lesson have been achieved. This is done by asking the following questions:-

- State the kinetic theory of gases
- List the state of matter

STEP 7: The teachers gives students the following assignment –

- Why does a gas in a container exert pressure?

LECTURE METHOD LESSON NOTE 2

TOPIC: Charles and Boyle's laws

CLASS: SSS II

TIME: 2 PERIODS OF 40 MINUTES EACH

SEX: MIXED

AGE: 15^+

INSTRUCTIONAL MATERIALS: New Senior Secondary School Chemistry by Ababio, Charts, Whiteboard and Black ink Marker.

BEHAVIOURAL OBJECTIVES: By the end of the lesson the students should be able to:-

i. State Charles' Law
ii. Express Charles' Law Mathematically
iii. Do simple calculations involving Charles' Law
iv. State Boyle's Law
v. Express Boyle's Law Mathematically
vi. Do simple calculations involving Boyle's Law

ENTRY BEHAVIOUR: Students already have the knowledge of the concept of kinetic theory of matter.

LESSON DEVELOPMENT

STEP 1: The teacher gains students' attention by asking questions such as State Charles and Boyle's Laws.

STEP 2: The teacher makes students aware of objectives of the lesson.

STEP 3: The teacher introduces the lesson by writing the topic on the whiteboard.

STEP 4: The teacher develops the topic of the lesson as follows:

CHARLES' LAW

Charles's law states that if a given quantity of gas is held at a constant pressure, its volume is directly proportional to the absolute temperature. The volume of the gas decreases as the temperature decreases and increases as the temperature increases. Charles' Law is mathematically expressed as shown below -

$V = kT$

Or $V/T = k$ (that is $V_1/T_1 = V_2/T_2$)

Where V is the volume, T is Kelvin temperature and K is a mathematical constant.

Simple Calculation involving Charles' Law: A sample of gas at 15ºC and 1 atm has a volume of 2.50 L. What volume will this gas occupy at 30ºC and 1 atm?

Solution

The pressure remains the same, while the volume and temperature change—this is the hallmark of a Charles's law question.

So then, $2.50\ L/288K = V_2/303K$, and $V_2 = 2.63L$

BOYLE'S LAW

Boyle's Law states that the volume of a given mass of gas is inversely proportional to its pressure, provided that the temperature remains constant. According to Boyle's law, volume of a gas increases as the pressure decreases and vice versa. This relationship is independent of the nature of the gas and it can be expressed mathematically as –

$V = k/P$

Or $PV = k$ (that is, $P_1V_1 = P_2V_2$)

Simple Calculation involving Boyle's Law: 375cm^2 of a gas has a pressure of 770mmHg. Find its volume if the pressure is reduced to 750mmHg.

Solution

$P_1V_1 = P_2V_2$

$V_2 = 385cm^2$

STEP 5: Teacher provides a summary of the lesson to enhance students learning process.

STEP 6: The teacher evaluates the students to determine the extent to which the objectives of lesson have been achieved. This is done by asking the following questions:-

- State Charles and Boyle's Laws
- Express Charles and Boyle's Laws mathematically

STEP 7: The teachers gives students the following assignment –

- A gas sample of argon, maintained at constant temperature, occupies a volume of 500 L at 4.00 atm. What is the new volume if the pressure were charged to 8 atm?

LECTURE METHOD LESSON NOTE 3

TOPIC: General Gas Equation

CLASS: SSS II

TIME: 2 PERIODS OF 40 MINUTES EACH

SEX: MIXED

AGE: 15^+

INSTRUCTIONAL MATERIALS: New Senior Secondary School Chemistry by Ababio, Charts, Whiteboard and Black ink Marker.

BEHAVIOURAL OBJECTIVES: By the end of the lesson the students should be able to:-

i. State General Gas Law

ii. Derive General Gas Equation

iii. Solve simple calculations involving General Gas Equation

ENTRY BEHAVIOUR: Students can state Charles and Boyle's Laws correctly.

LESSON DEVELOPMENT

STEP 1: The teacher gains students' attention by asking questions such as, what is General Gas Equation?

STEP 2: The teacher makes students aware of objectives of the lesson.

STEP 3: The teacher introduces the lesson by writing the topic on the whiteboard.

STEP 4: The teacher develops the topic of the lesson as follow -

GENERAL GAS LAW

Boyle's and Charles's laws are combined to form the *general gas law.* This law states: *The product of the initial pressure, initial volume, and new temperature (absolute scale) of an enclosedgasisequaltotheproductofthenewpressure,newvolume, and initial temperature.* It is a mathematical statement which allows many gas problems to be solved by using the principles of Boyle's law and/or Charles's law. The equation is expressed mathematically as shown below

$\mathbf{P_1V_1/T_1 = P_2V_2/T_2}$

Where P_1, V_1 and T_1 are initial pressure, volume and temperature while P_2, V_2 and T_2 are final pressure, volume and temperature.

DERIVATION OF GENERAL GAS EQUATION

Given that, PV/nT = constant

For initial conditions: When temperature is T_1 and pressure is P_1:

$\mathbf{P_1V_1/T_1}$ **= constant ----------------- (a)**

Similarly for final conditions: When temperature is T_2 and pressure is P_2

$\mathbf{P_2V_2/T_2}$ **= constant ----------------- (b)**

From equation (a) & (b)

$\mathbf{P_1V_1/T_1 = P_2V_2/T_2}$

Simple Calculation Involving General Gas Equation: At s.t.p, a certain mass of gas occupies a volume of $790cm^2$. Find the temperature at which the gas occupies $1000cm^2$ and has a pressure of 726mmHg.

Solution

$\mathbf{P_1V_1/T_1 = P_2V_2/T_2}$

$T_2 = 330.1K$

STEP 5: Teacher provides a summary of the lesson to enhance students learning process.

STEP 6: The teacher evaluates the students to determine the extent to which the objectives of lesson have been achieved. This is done by asking the following questions:-

- State General Gas Law
- Derive General Gas Equation

STEP 7: The teachers gives students the following assignment –

- A gas under 25 atm pressure occupies 35.0 L at 127°C. What is the volume of the gas under standard conditions (1 atm, 0°C)?

APPENDIX IV

Respondents' Demographic Data

GENDER		
Gender	**Frequency**	**Percentage**
Male	232	54.21%
Female	196	45.79%
Total	**428**	**100%**
GROUP		
Group	**Frequency**	**Percentage**

Experimental	229	53.50%
Control	199	46.50%
Total	**428**	**100%**
AGE		
Age Range	**Frequency**	**Percentage**
10-15 Years	238	55.61%
16-20 Years	190	44.39%
Total	**428**	**100%**

APPENDIX V

TEST OF NORMALITY

This test was used to check the distribution of scores for each of our groups of independent variables. This test ensures that the populations from which our samples are taken are normally distributed. The result is shown below:

Hypothesis 1
Group

Case Processing Summary

Group		Cases				
		Valid		Missing		Total
		N	Percent	N	Percent	N
Scores	Pre-Test 5E Learning Scores	229	100.0%	0	0.0%	229
	Post-Test 5E Learning Scores	229	100.0%	0	0.0%	229

Case Processing Summary

Group		Cases
		Total
		Percent
Scores	Pre-Test 5E Learning Scores	100.0%
	Post-Test 5E Learning Scores	100.0%

Descriptives

Group				Statistic	Std. Error
Scores	Pre-Test 5E Learning Scores	Mean		28.54	.500
		95% Confidence Interval for Mean	Lower Bound	27.56	
			Upper Bound	29.53	
		5% Trimmed Mean		28.43	
		Median		30.00	
		Variance		57.346	
		Std. Deviation		7.573	
		Minimum		18	
		Maximum		41	
		Range		23	

	Interquartile Range		10	
	Skewness		.376	.161
	Kurtosis		-1.109	.320
Post-Test 5E Learning Scores	Mean		42.43	.250
	95% Confidence Interval for Mean	Lower Bound	41.93	
		Upper Bound	42.92	
	5% Trimmed Mean		42.59	
	Median		42.00	
	Variance		14.351	
	Std. Deviation		3.788	
	Minimum		30	
	Maximum		49	
	Range		19	
	Interquartile Range		5	
	Skewness		-.483	.161
	Kurtosis		.858	.320

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk	
	Group	Statistic	df	Sig.	Statistic	df
Scores	Pre-Test 5E Learning Scores	.178	229	.000	.897	229
	Post-Test 5E Learning Scores	.156	229	.000	.942	229

Tests of Normality

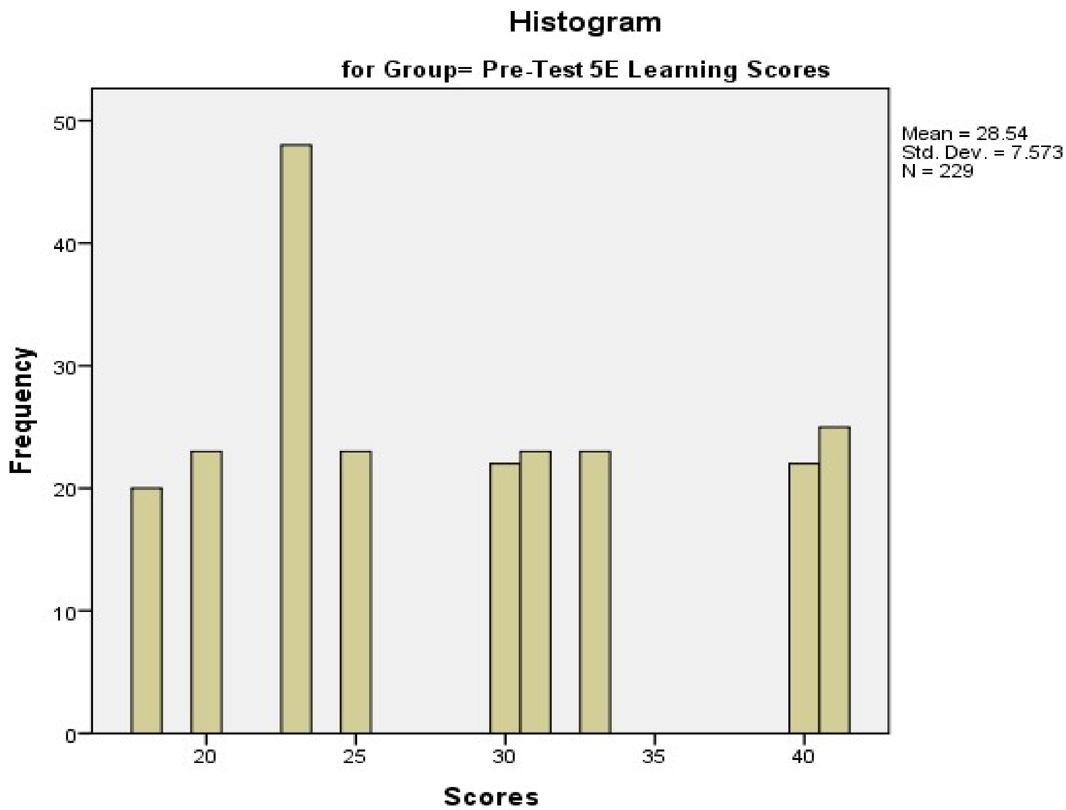
		Shapiro-Wilk[a]
	Group	Sig.
Scores	Pre-Test 5E Learning Scores	.000

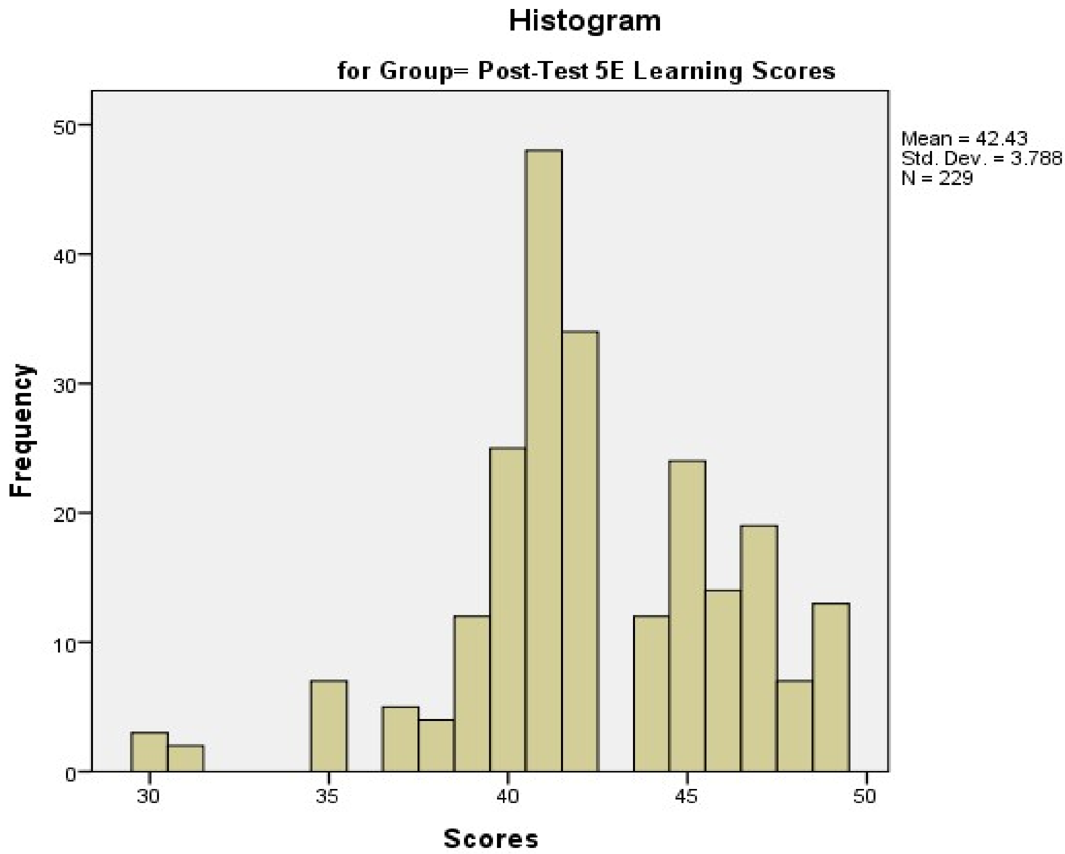
	Post-Test 5E Learning Scores	.000

a. Lilliefors Significance Correction

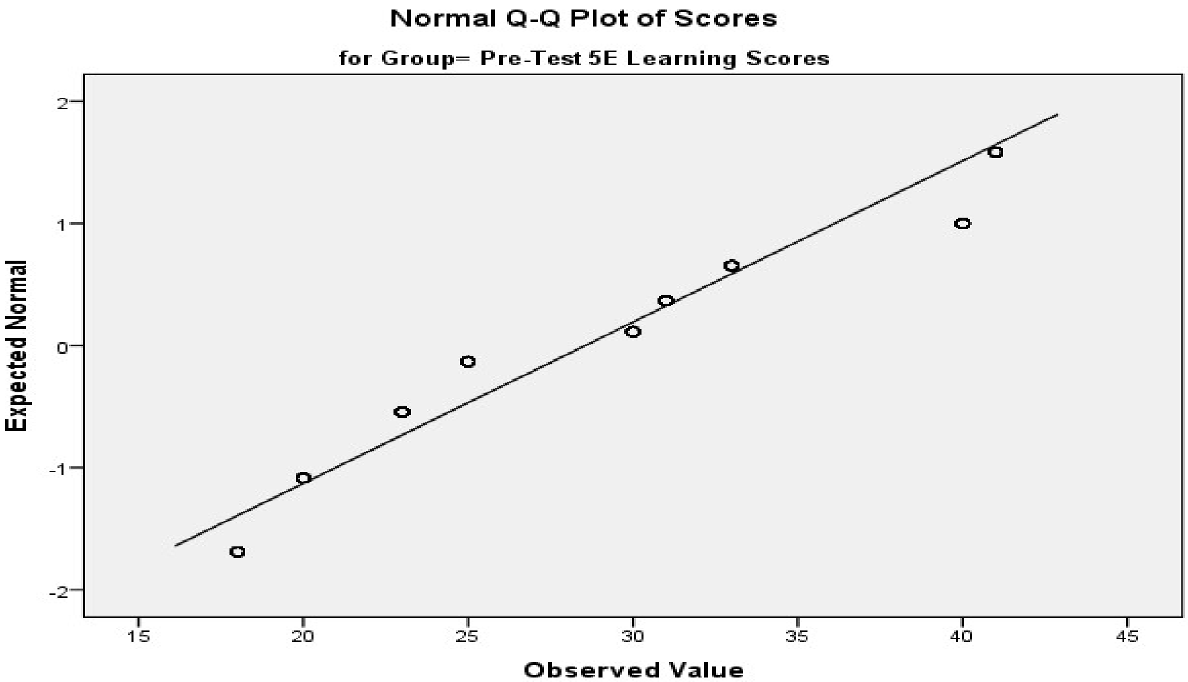
Scores

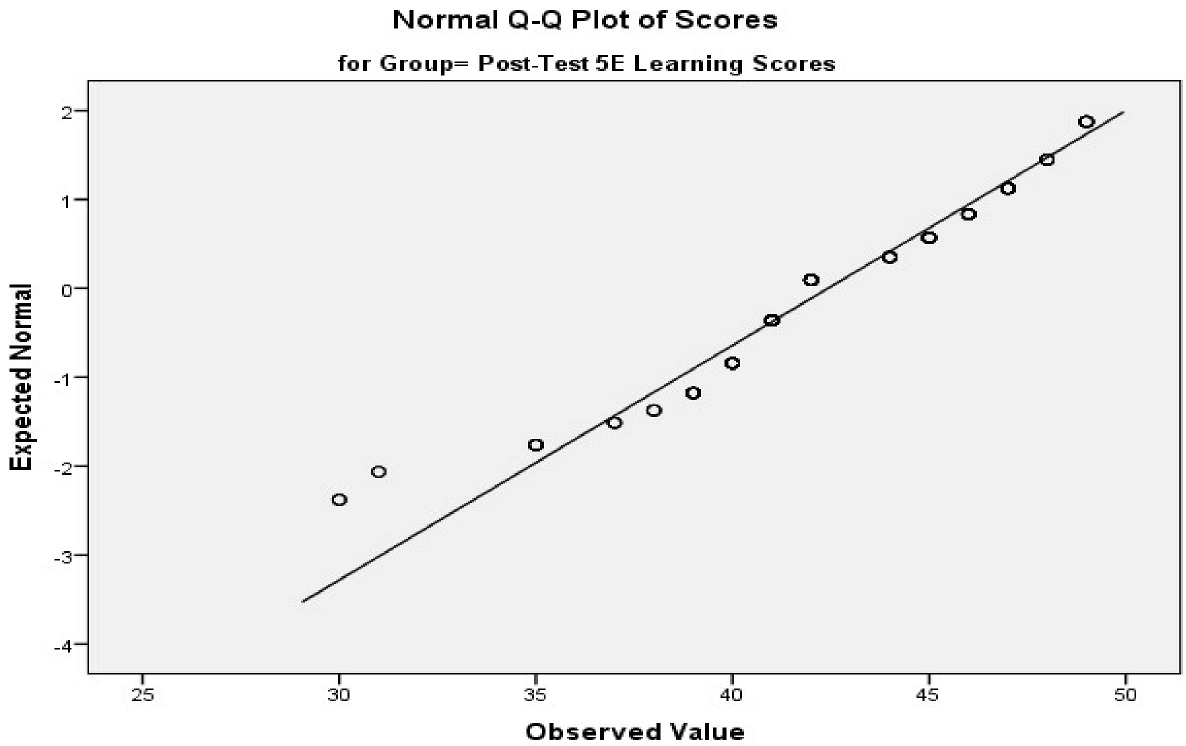
Histograms



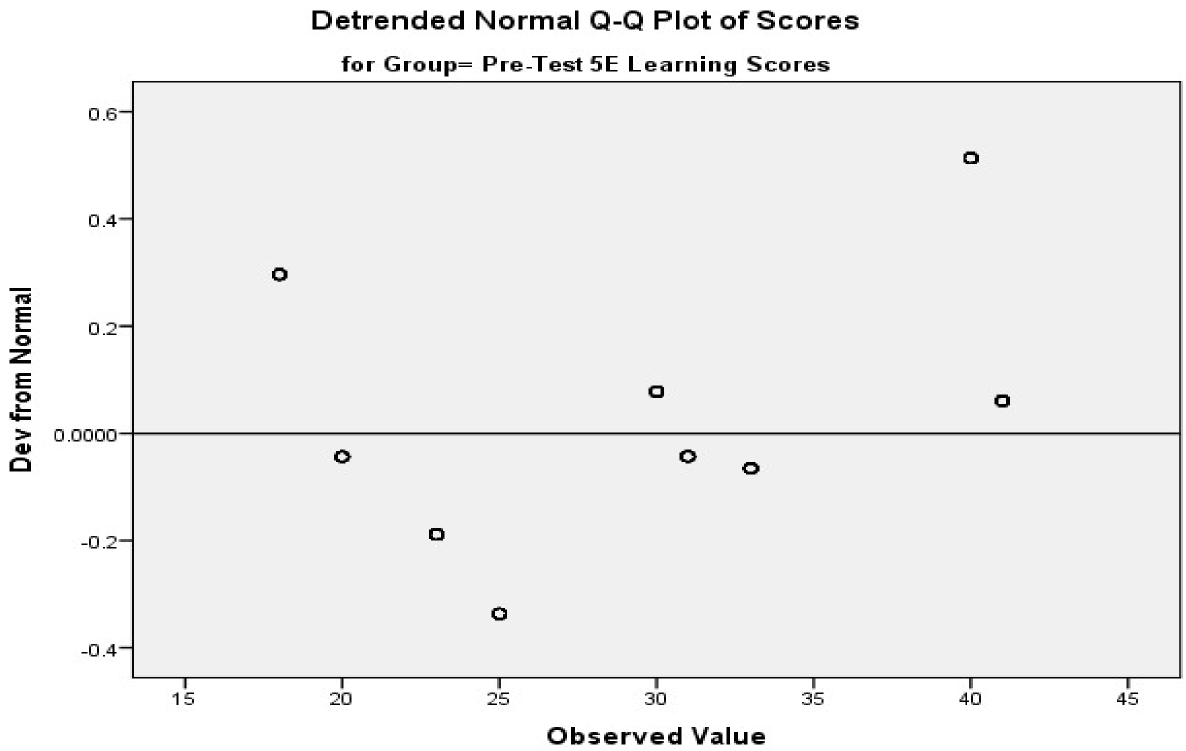


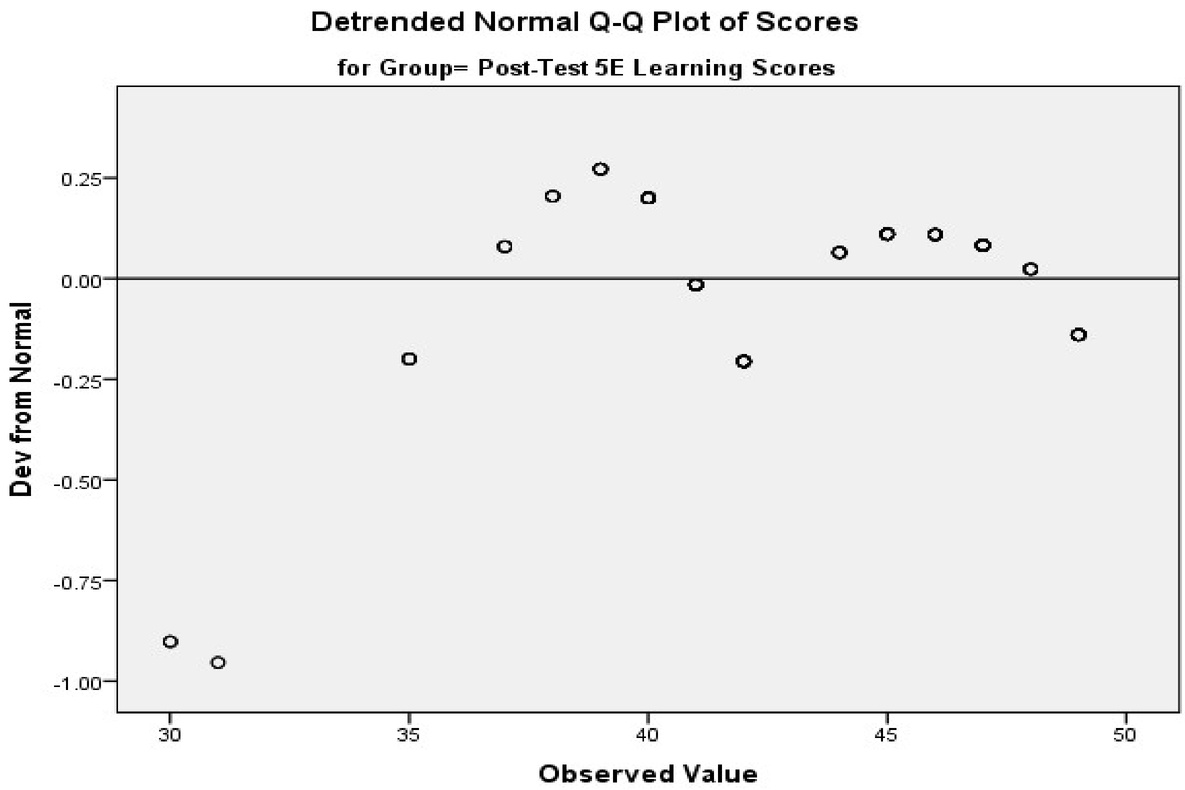
Normal Q-Q Plots

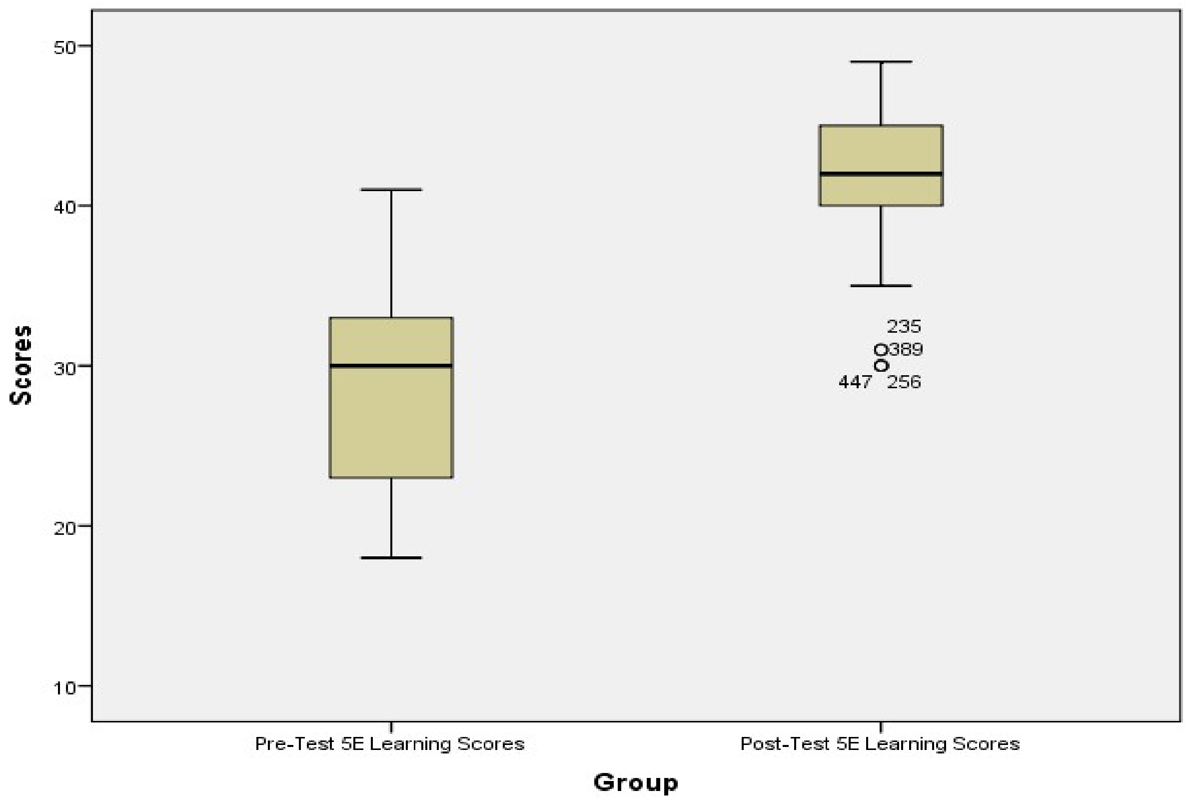




Detrended Normal Q-Q Plots




Detrended Normal Q-Q Plot of Scores
for Group= Post-Test 5E Learning Scores
Dev from Normal
0.25
0.00
-0.25
-0.50
-0.75
-1.00
30
35
40
45
50
Observed Value


Scores
50
40
30
20
10
235
389
447
256
Pre-Test 5E Learning Scores
Post-Test 5E Learning Scores
Group

Hypothesis 2
Method

Case Processing Summary

	Method	Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Chemistry	5E Learning Cycle	229	100.0%	0	0.0%	229	100.0%
	Lecure Method	199	100.0%	0	0.0%	199	100.0%

Descriptives

	Method			Statistic	Std. Error
Chemistry	5E Learning Cycle	Mean		42.43	.250
		95% Confidence Interval for Mean	Lower Bound	41.93	
			Upper Bound	42.92	
		5% Trimmed Mean		42.59	
		Median		42.00	
		Variance		14.351	
		Std. Deviation		3.788	
		Minimum		30	
		Maximum		49	
		Range		19	
		Interquartile Range		5	
		Skewness		-.483	.161
		Kurtosis		.858	.320
	Lecure Method	Mean		32.53	.314
		95% Confidence Interval for Mean	Lower Bound	31.91	
			Upper Bound	33.15	

	5% Trimmed Mean	32.71	
	Median	32.00	
	Variance	19.644	
	Std. Deviation	4.432	
	Minimum	20	
	Maximum	45	
	Range	25	
	Interquartile Range	6	
	Skewness	-.454	.172
	Kurtosis	.496	.343

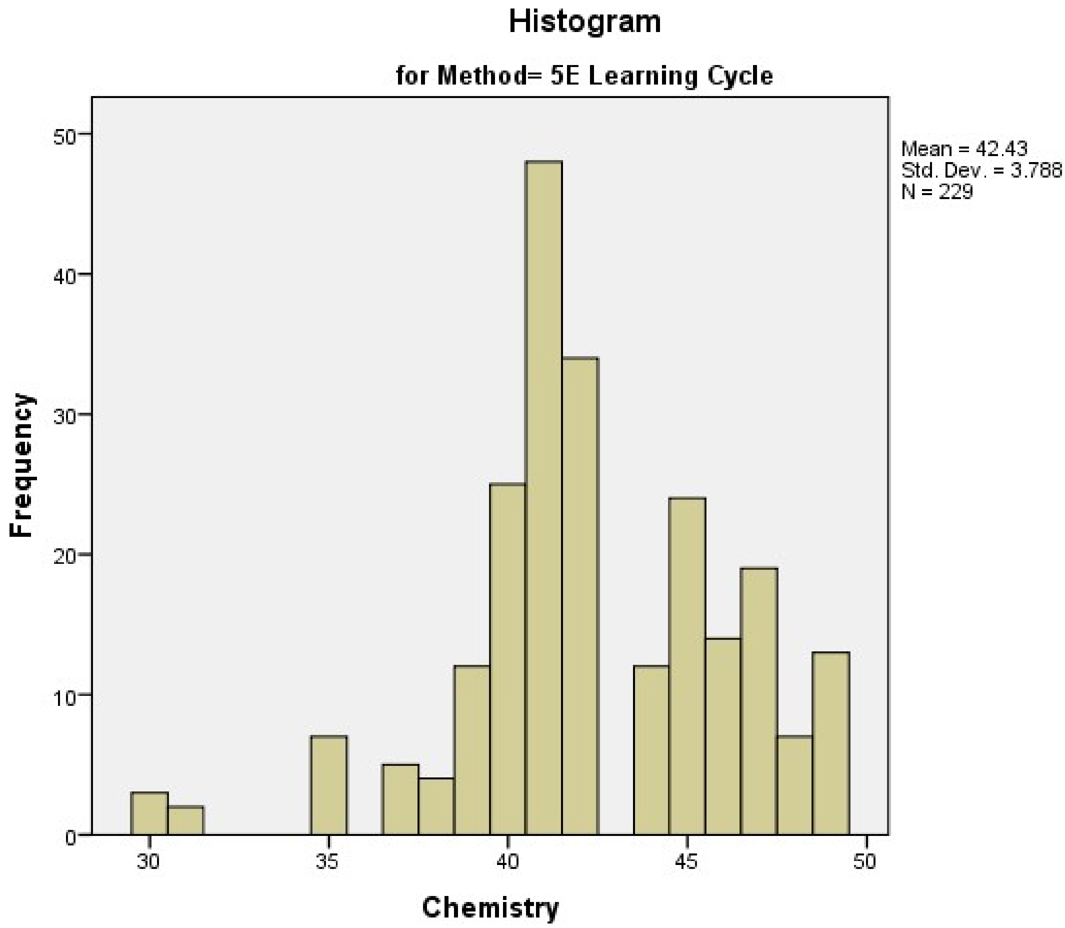
Tests of Normality

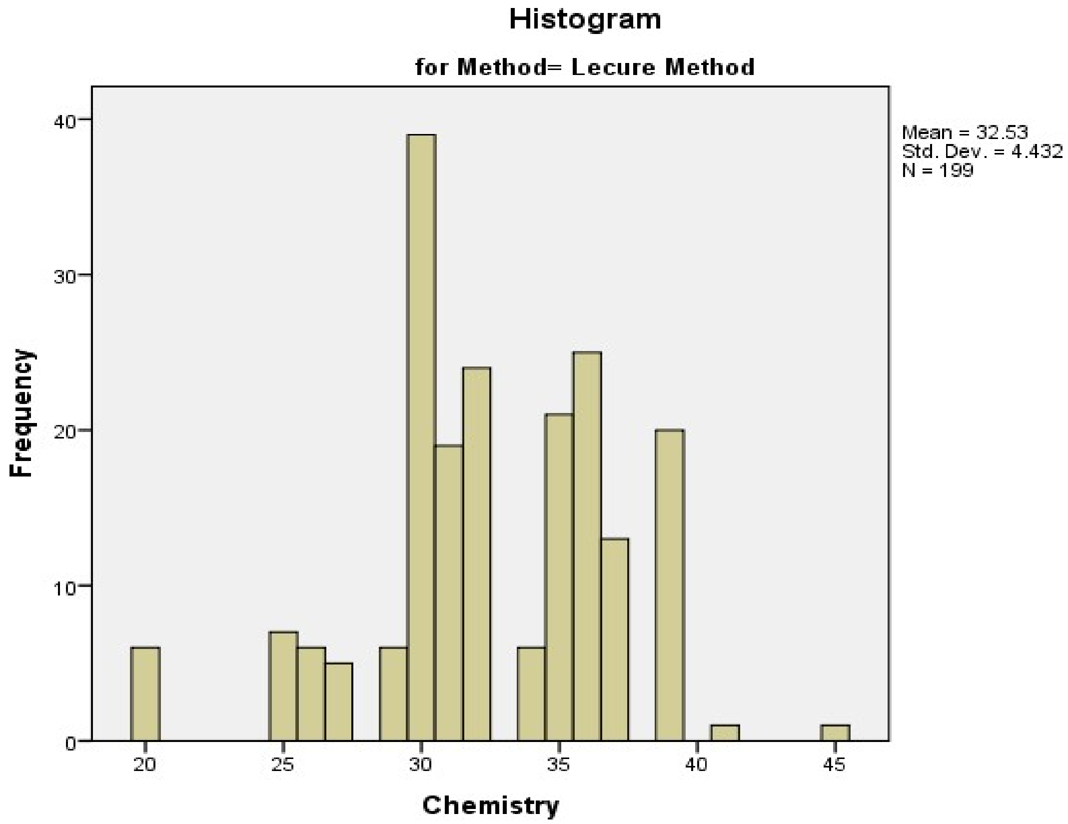
	Method	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Chemistry	5E Learning Cycle	.156	229	.000	.942	229	.000
	Lecure Method	.133	199	.000	.951	199	.000

a. Lilliefors Significance Correction

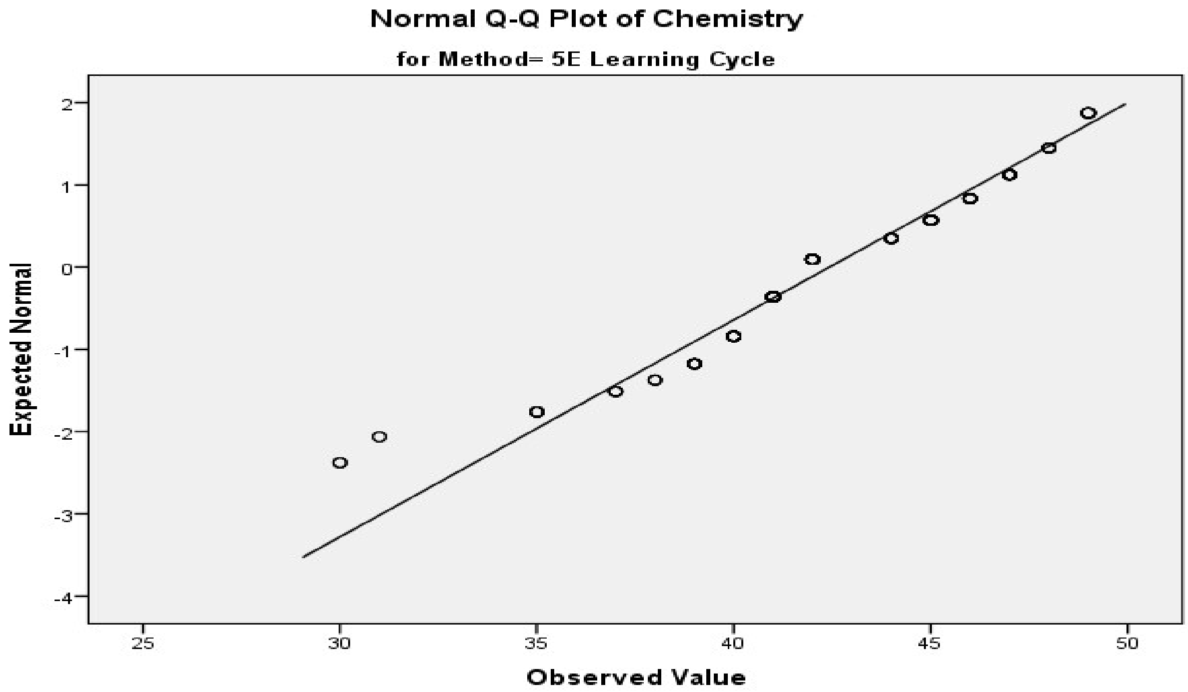
Chemistry

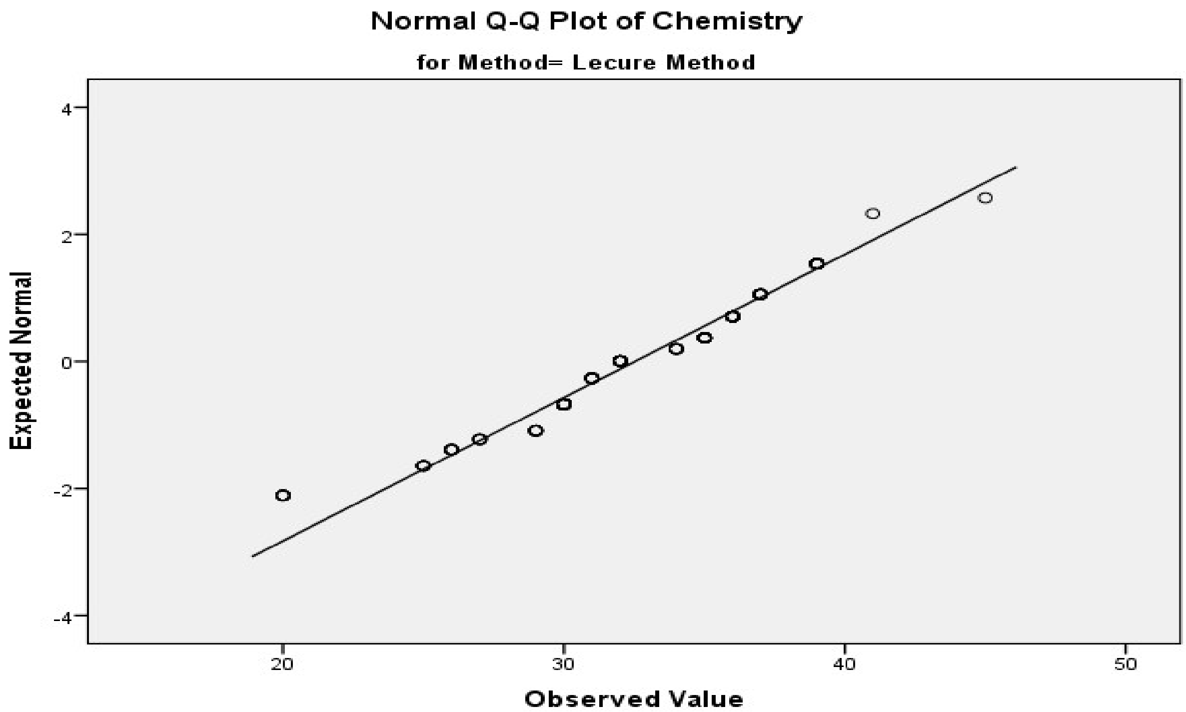
Histograms



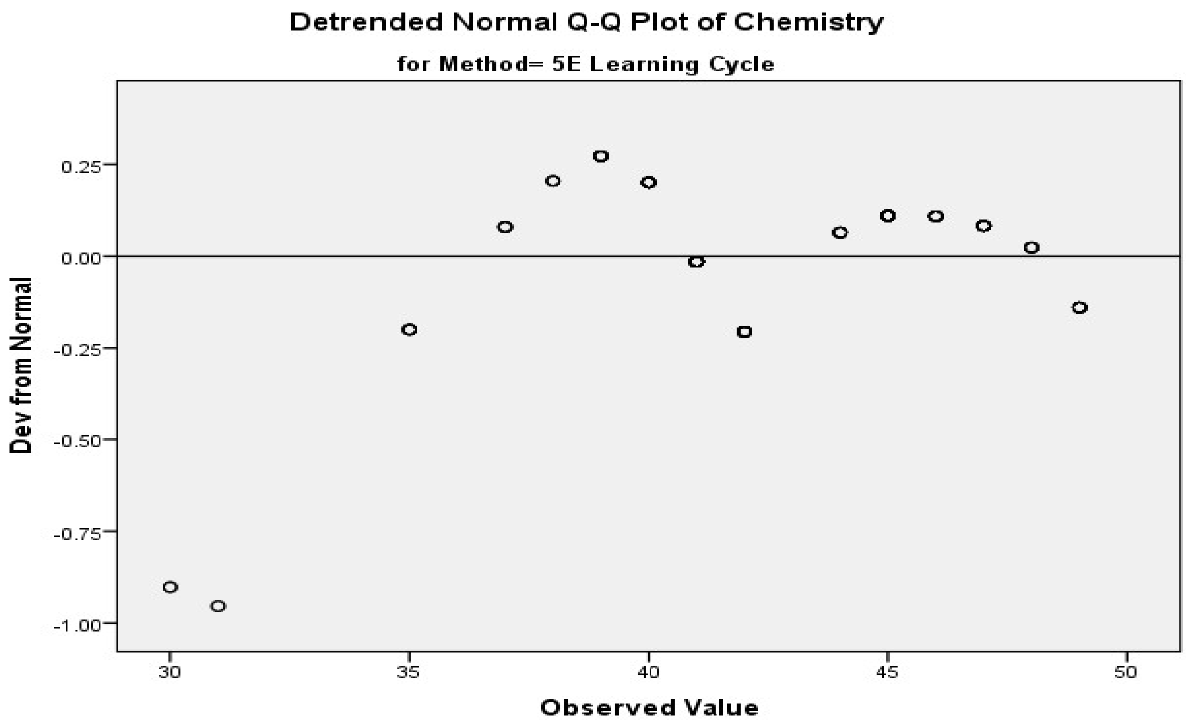


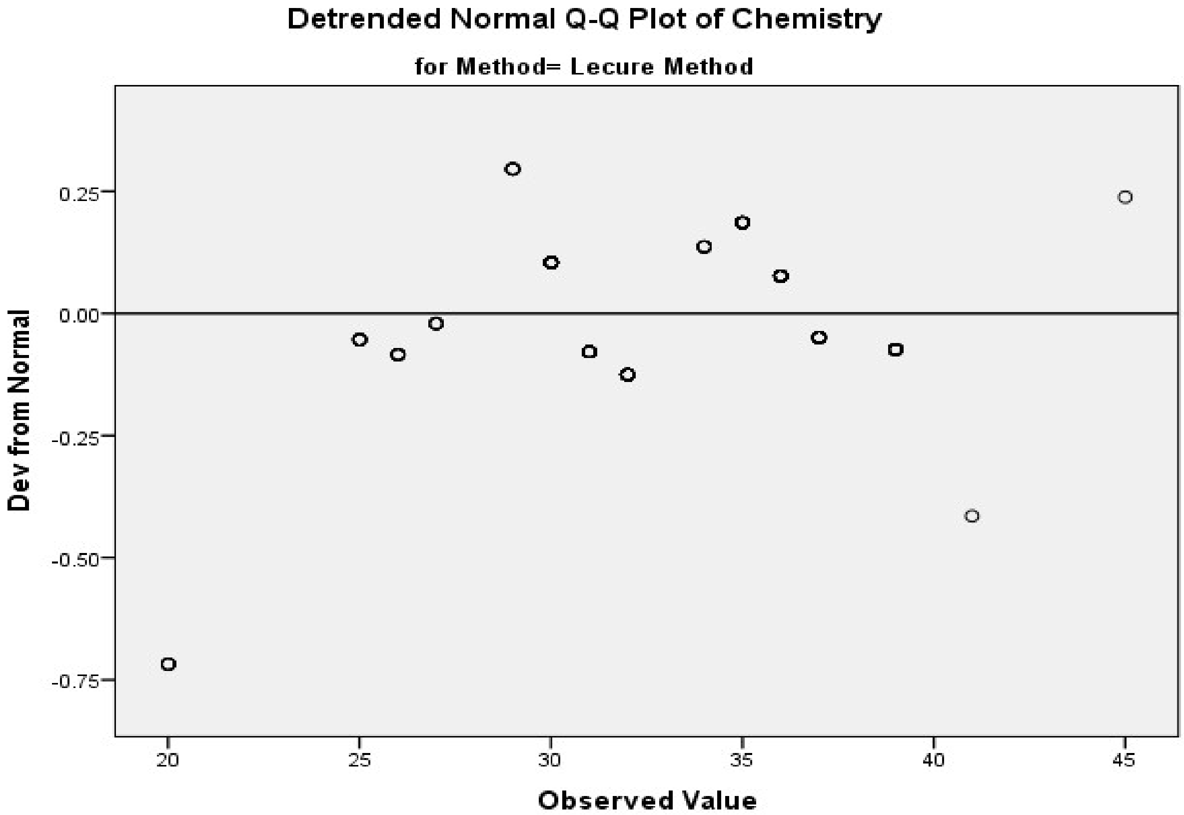
Normal Q-Q Plots



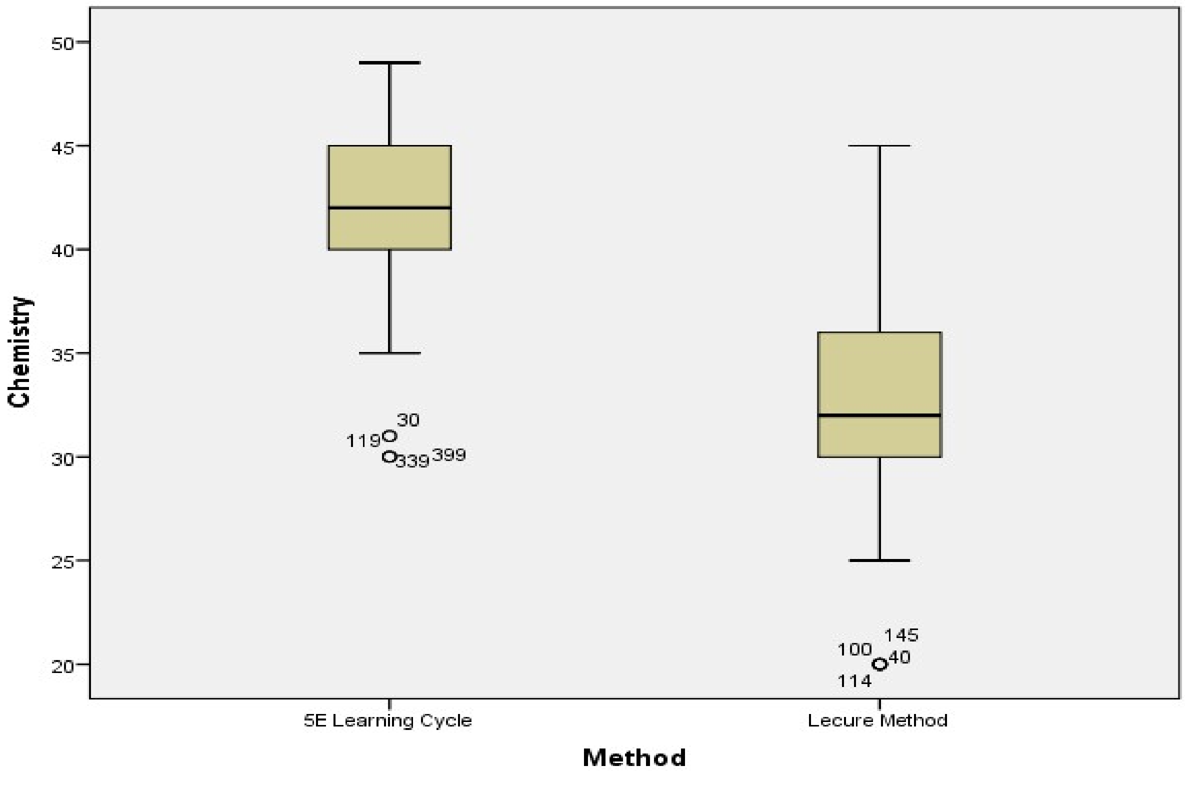


Detrended Normal Q-Q Plots





Detrended Normal Q-Q Plot of Chemistry
for Method= Lecure Method
Dev from Normal
0.25
0.00
-0.25
-0.50
-0.75
20
25
30
35
40
45
Observed Value



Chemistry
50
45
40
35
30
25
20
30
119
339
399
145
100
40
114
5E Learning Cycle
Lecure Method
Method

Hypothesis 3
Gender

Case Processing Summary

	Gender	Cases				
		Valid		Missing		Total
		N	Percent	N	Percent	N
chemistry achievement of Students Taught with 5E learning cycle	Male	129	100.0%	0	0.0%	129
	Female	100	100.0%	0	0.0%	100

Case Processing Summary

	Gender	Cases
		Total
		Percent
chemistry achievement of Students Taught with 5E learning cycle	Male	100.0%
	Female	100.0%

Descriptives

Gender				Statistic	Std. Error
chemistry achievement of Students Taught with 5E learning cycle	Male	Mean		42.08	.325
		95% Confidence Interval for Mean	Lower Bound	41.43	
			Upper Bound	42.72	
		5% Trimmed Mean		42.20	
		Median		41.00	
		Variance		13.635	
		Std. Deviation		3.693	
		Minimum		30	

				Statistic	Std. Error
		Maximum		49	
		Range		19	
		Interquartile Range		5	
		Skewness		-.420	.213
		Kurtosis		.906	.423
	Female	Mean		42.88	.388
		95% Confidence Interval for Mean	Lower Bound	42.11	
			Upper Bound	43.65	
		5% Trimmed Mean		43.09	
		Median		42.00	
		Variance		15.056	
		Std. Deviation		3.880	
		Minimum		30	
		Maximum		49	
		Range		19	
		Interquartile Range		5	
		Skewness		-.610	.241
		Kurtosis		1.044	.478

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk	
	Gender	Statistic	df	Sig.	Statistic	df
chemistry achievement of Students Taught with 5E learning cycle	Male	.160	129	.000	.947	129
	Female	.150	100	.000	.933	100

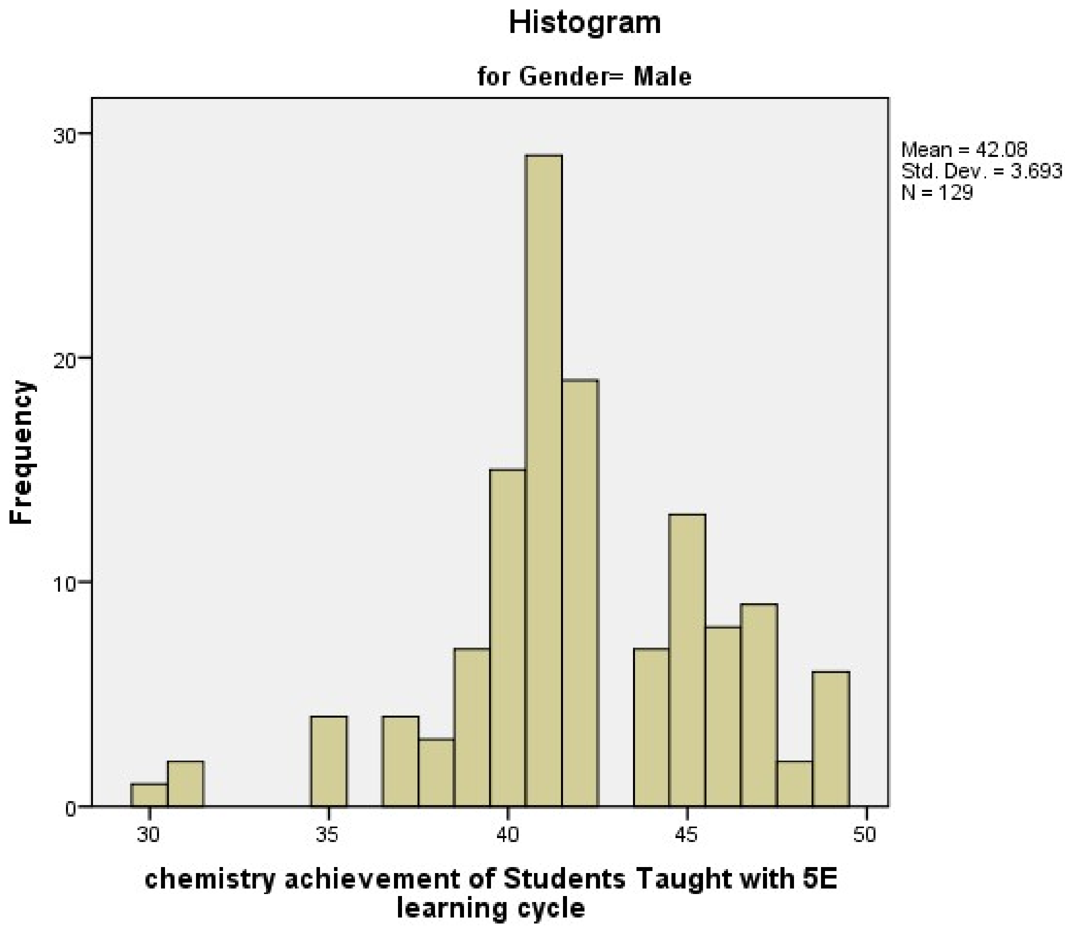
Tests of Normality

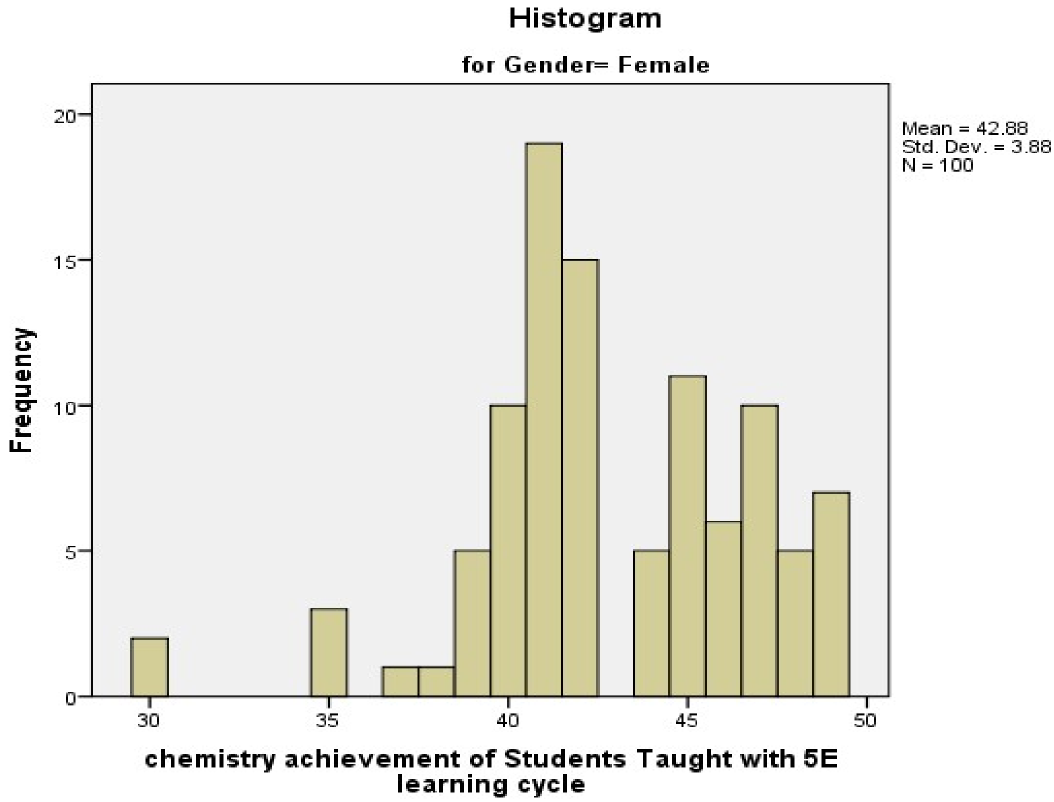
	Gender	Shapiro-Wilk[a]
		Sig.
chemistry achievement of Students Taught with 5E learning cycle	Male	.000
	Female	.000

a. Lilliefors Significance Correction

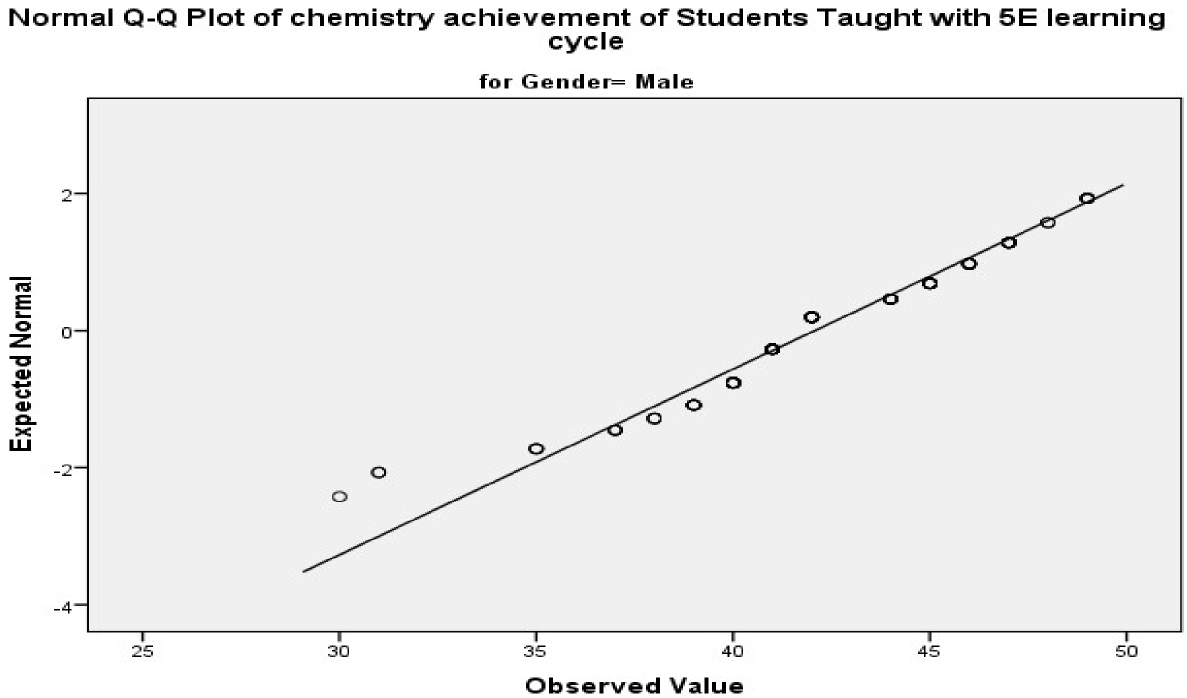
chemistry achievement of Students Taught with 5E learning cycle

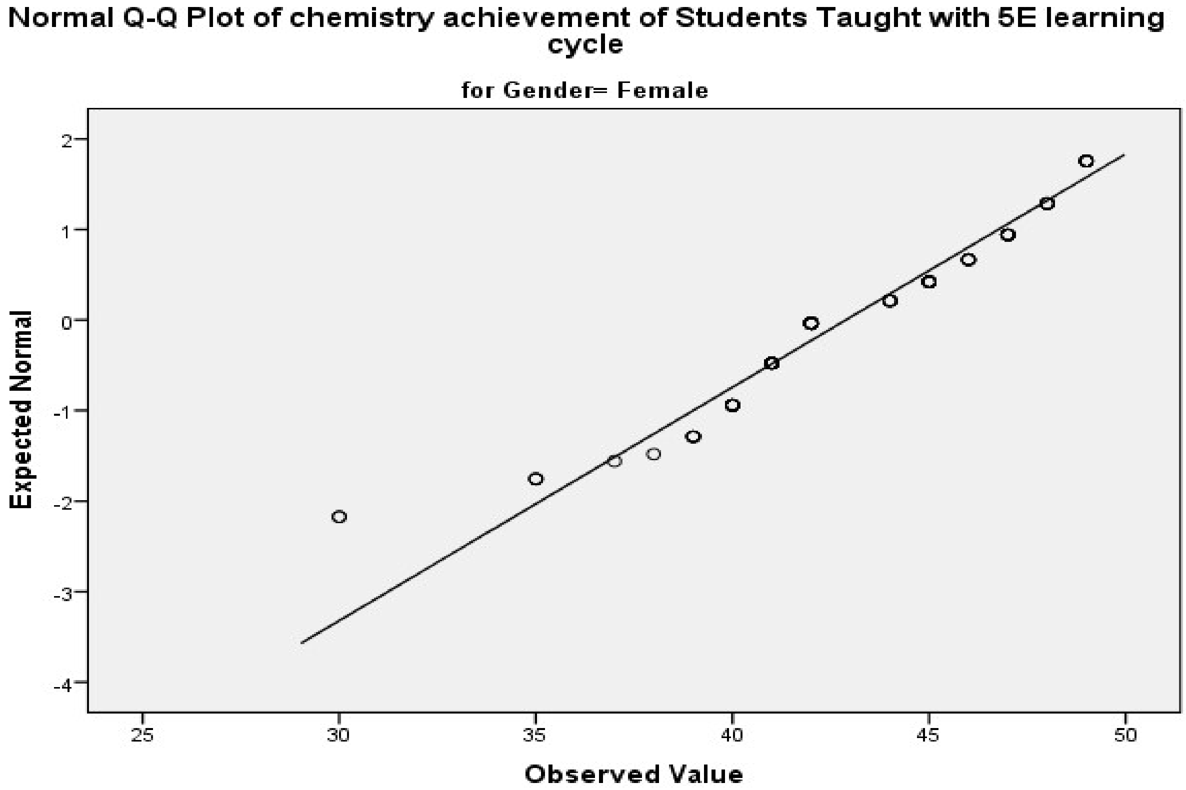
Histograms



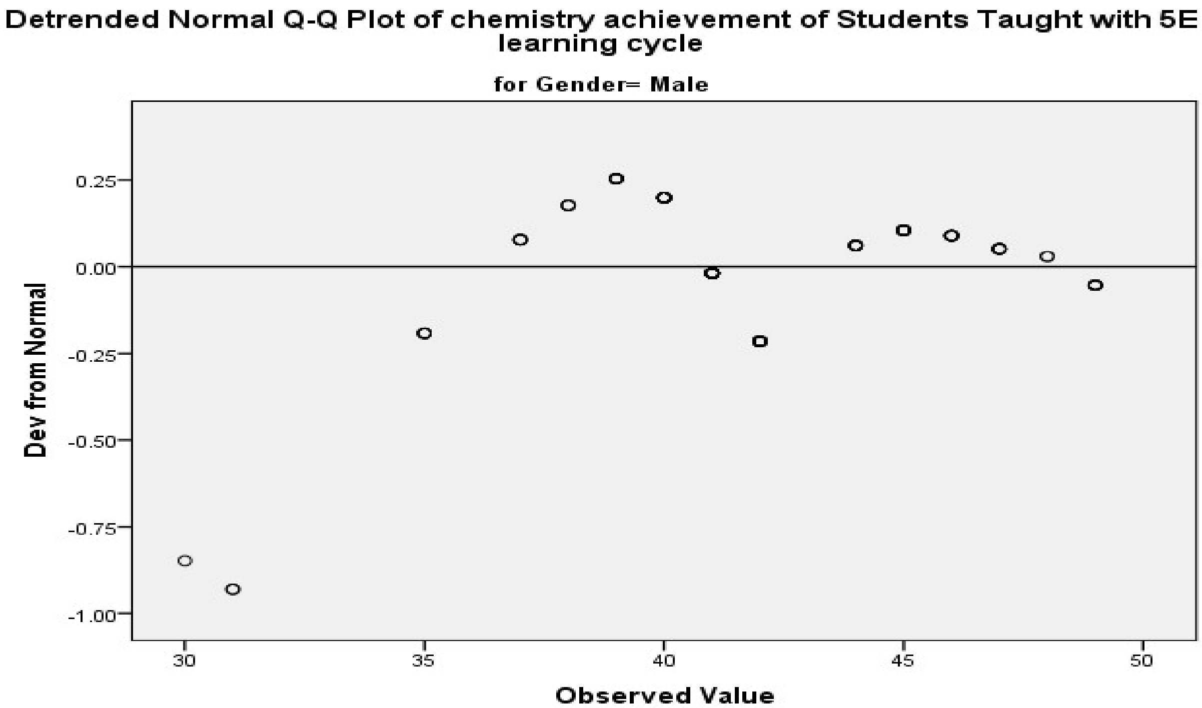


Normal Q-Q Plots



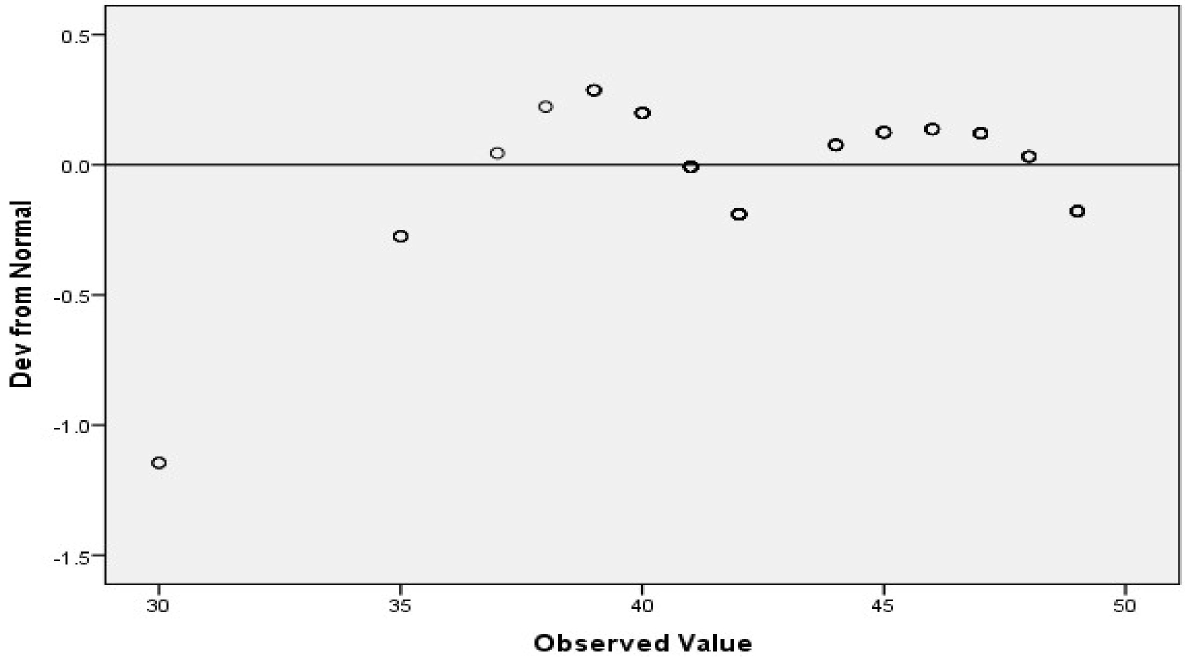


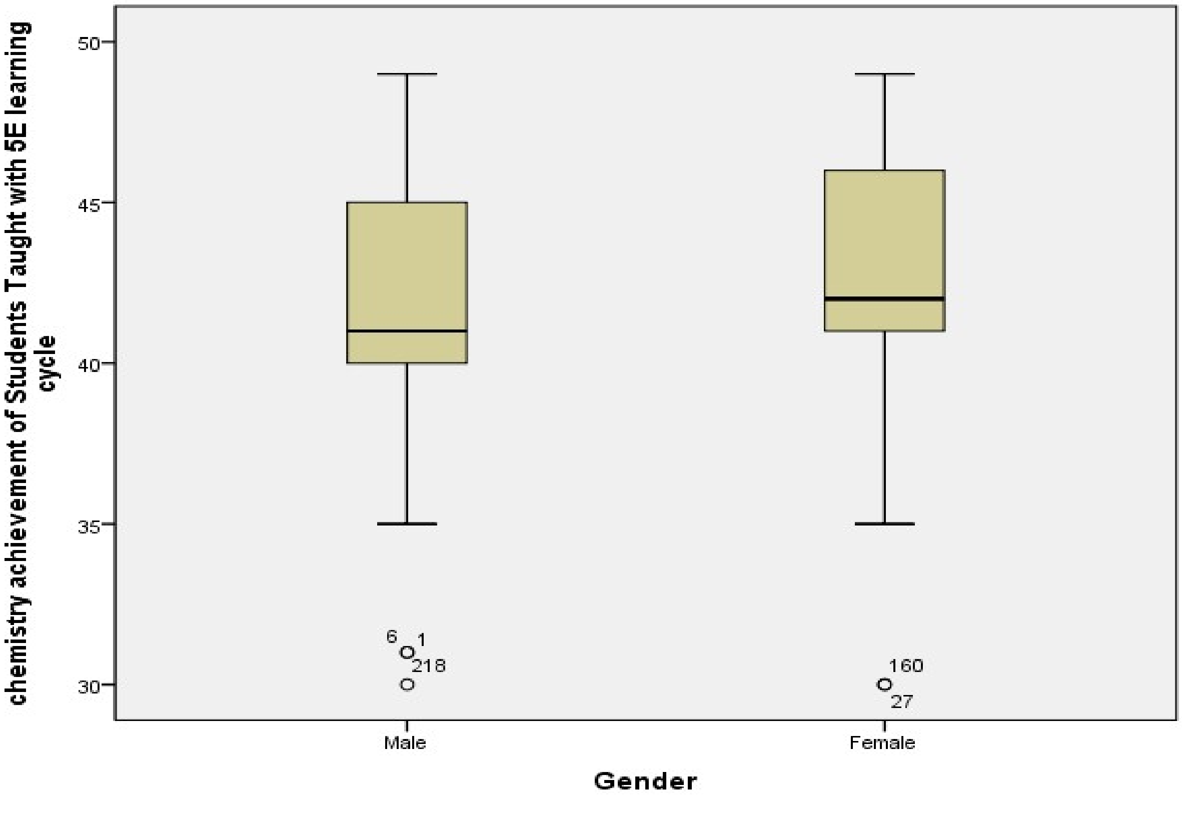
Detrended Normal Q-Q Plots



Detrended Normal Q-Q Plot of chemistry achievement of Students Taught with 5E learning cycle

for Gender= Female





Hypothesis 4
Age

Case Processing Summary

	Age	Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
chemistry achievement of Students Taught with 5E learning cycle	10-15	127	100.0%	0	0.0%	127	100.0%
	16-20	102	100.0%	0	0.0%	102	100.0%

Descriptives

	Age			Statistic	Std. Error
chemistry achievement of Students Taught with 5E learning cycle	10-15	Mean		42.24	.345
		95% Confidence Interval for Mean	Lower Bound	41.55	
			Upper Bound	42.92	
		5% Trimmed Mean		42.38	
		Median		42.00	
		Variance		15.102	
		Std. Deviation		3.886	
		Minimum		30	
		Maximum		49	
		Range		19	
		Interquartile Range		5	
		Skewness		-.494	.215
		Kurtosis		.758	.427
	16-20	Mean		42.67	.363
		95% Confidence Interval for	Lower Bound	41.95	

	Mean Upper Bound	43.39	
	5% Trimmed Mean	42.81	
	Median	42.00	
	Variance	13.452	
	Std. Deviation	3.668	
	Minimum	30	
	Maximum	49	
	Range	19	
	Interquartile Range	4	
	Skewness	-.454	.239
	Kurtosis	1.078	.474

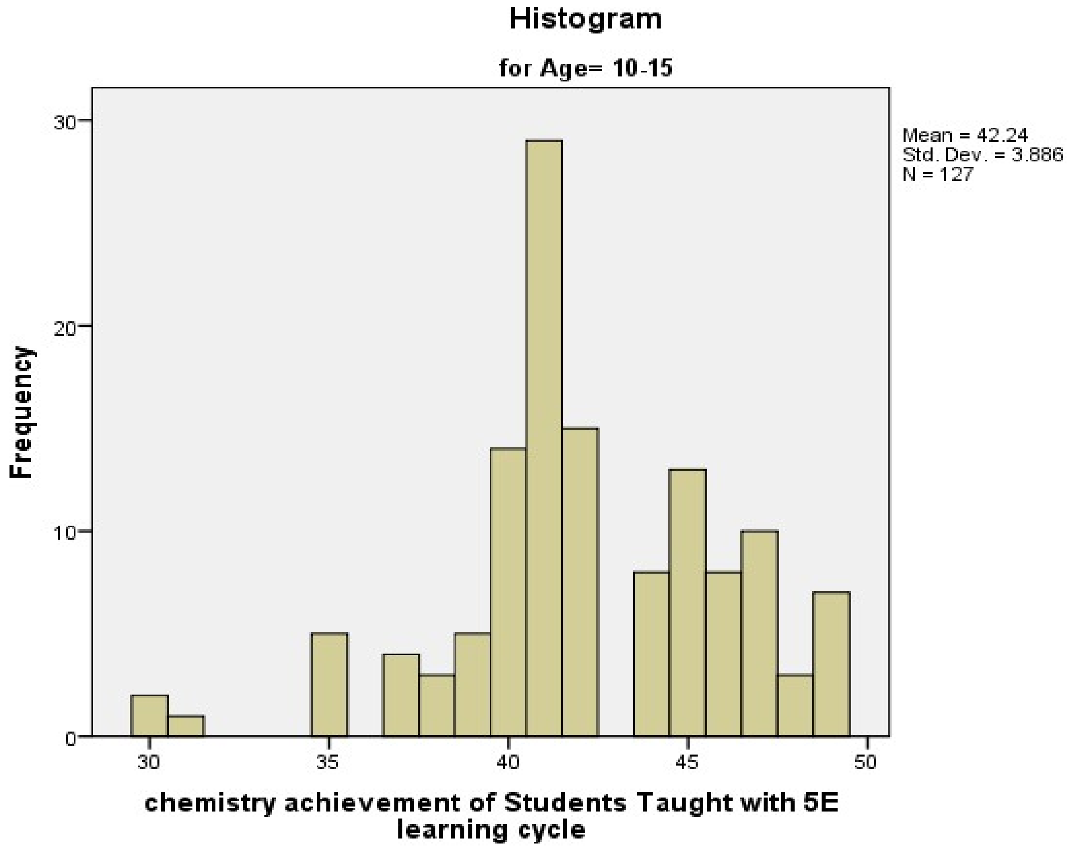
Tests of Normality

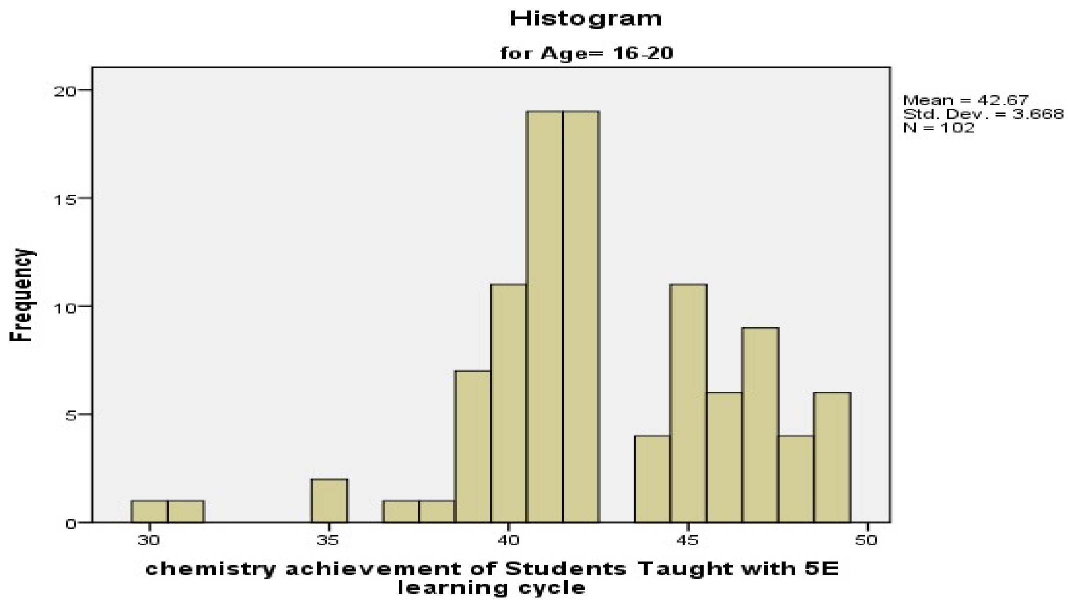
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Age	Statistic	df	Sig.	Statistic	df	Sig.
chemistry achievement of Students Taught with 5E learning cycle	10-15	.138	127	.000	.947	127	.000
	16-20	.180	102	.000	.935	102	.000

a. Lilliefors Significance Correction

chemistry achievement of Students Taught with 5E learning cycle

Histograms

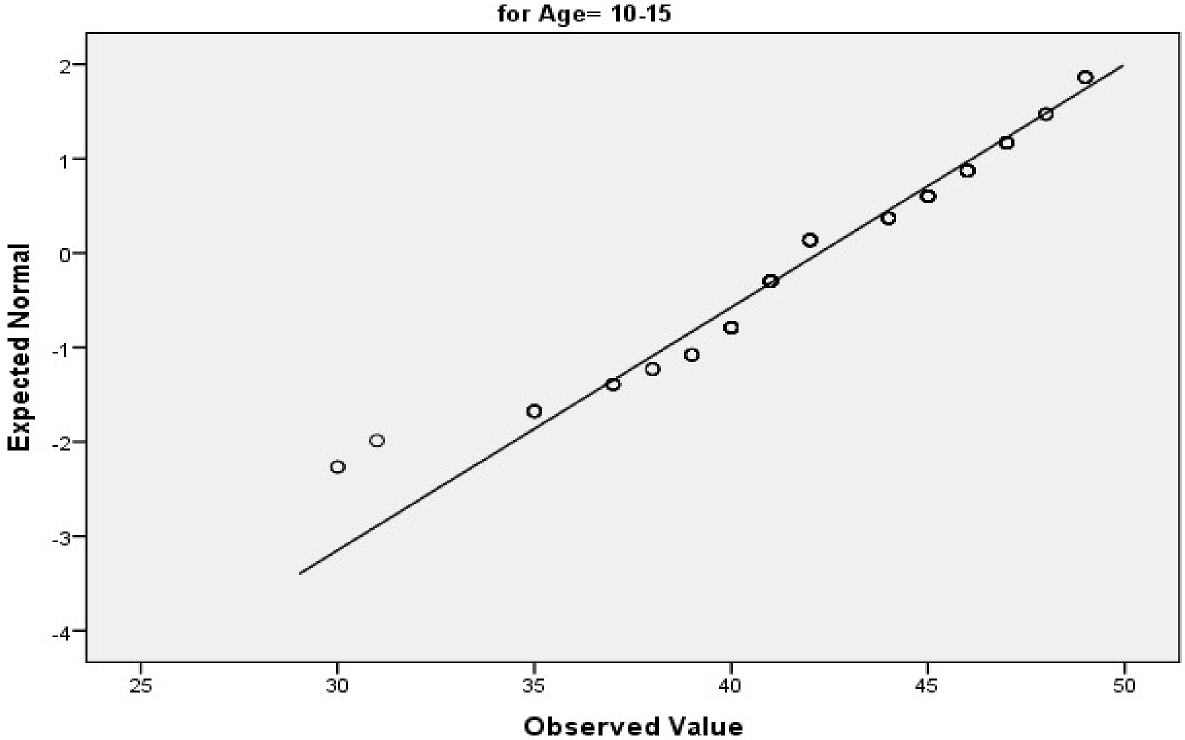




Normal Q-Q Plots

Normal Q-Q Plot of chemistry achievement of Students Taught with 5E learning cycle

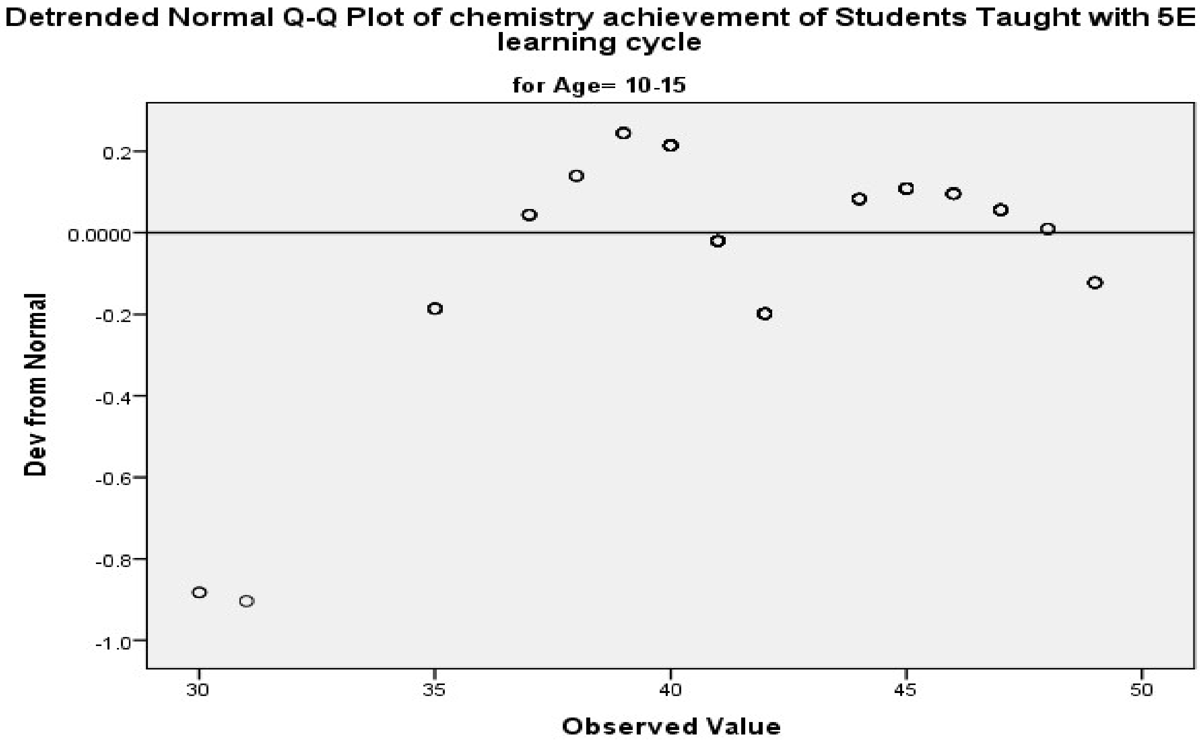
for Age= 10-15

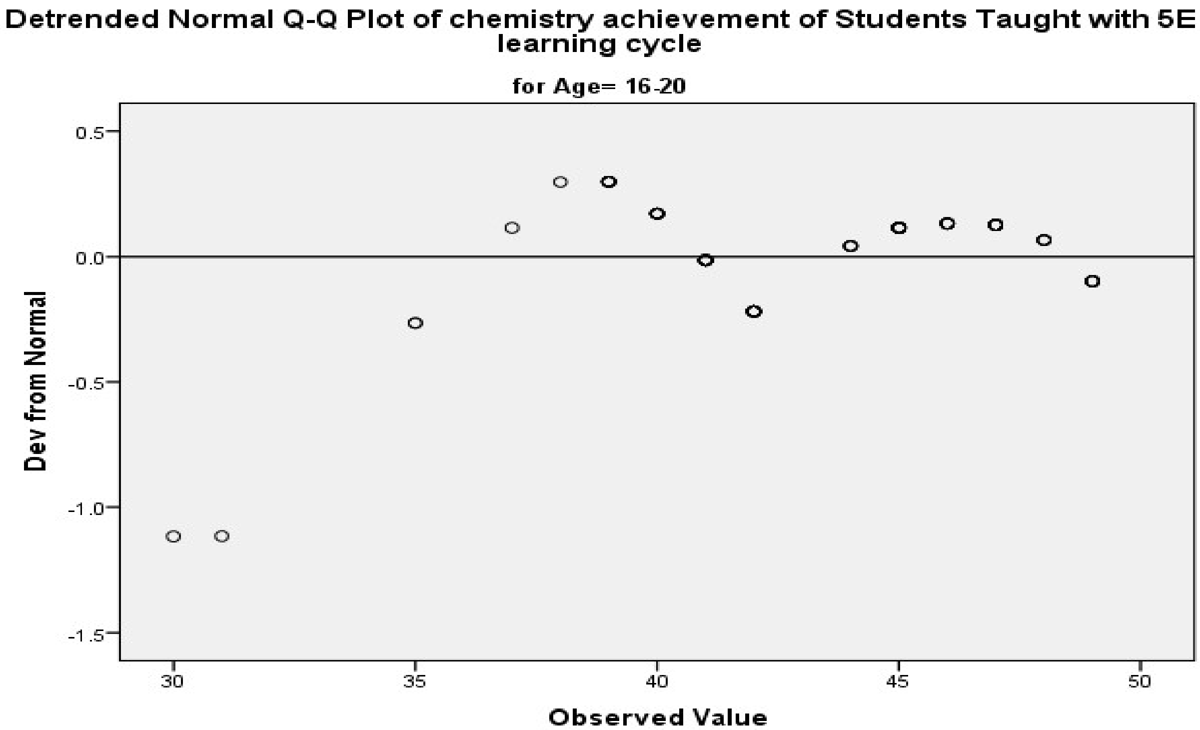


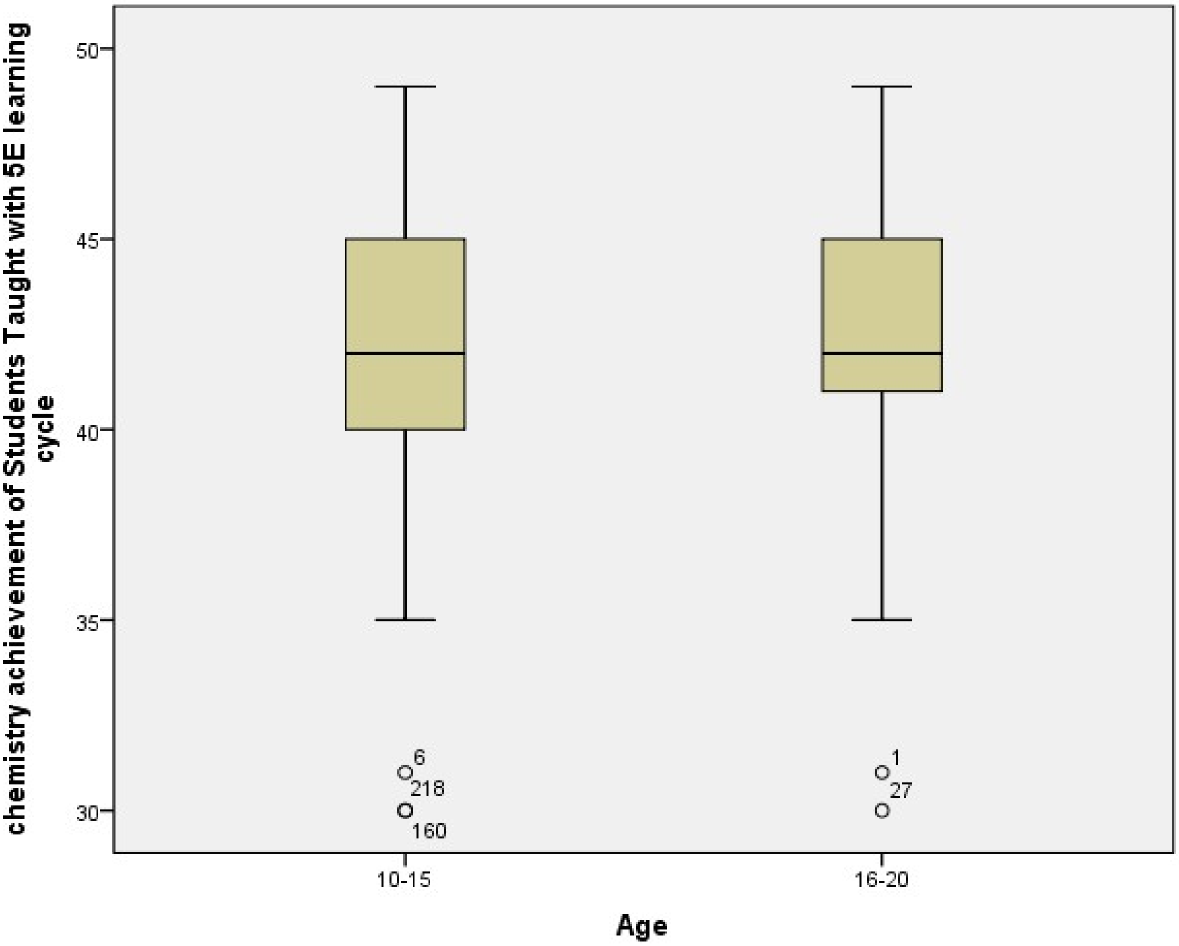
Normal Q-Q Plot of chemistry achievement of Students Taught with 5E learning cycle

for Age= 16-20

Detrended Normal Q-Q Plots


Detrended Normal Q-Q Plot of chemistry achievement of Students Taught with 5E learning cycle
for Age= 10-15
Dev from Normal
0.2
0.0000
-0.2
-0.4
-0.6
-0.8
-1.0
30
35
40
45
50
Observed Value


Detrended Normal Q-Q Plot of chemistry achievement of Students Taught with 5E learning cycle
for Age= 16-20
Dev from Normal
0.5
0.0
-0.5
-1.0
-1.5
30
35
40
45
50
Observed Value



Hypothesis 5

Gender

Case Processing Summary

		Cases					
		Valid		Missing		Total	
	Gender	N	Percent	N	Percent	N	Percent
Pre-Test Score	Male	232	100.0%	0	0.0%	232	100.0%
	Female	196	100.0%	0	0.0%	196	100.0%
Post-Test Score	Male	232	100.0%	0	0.0%	232	100.0%
	Female	196	100.0%	0	0.0%	196	100.0%

Descriptives

	Gender			Statistic	Std. Error
Pre-Test Score	Male	Mean		28.15	.495
		95% Confidence Interval for Mean	Lower Bound	27.17	
			Upper Bound	29.12	
		5% Trimmed Mean		28.00	
		Median		25.00	
		Variance		56.810	
		Std. Deviation		7.537	
		Minimum		18	
		Maximum		41	
		Range		23	
		Interquartile Range		10	
		Skewness		.417	.160
		Kurtosis		-1.042	.318
	Female	Mean		28.30	.539
		95% Confidence Interval for	Lower Bound	27.23	

		Mean	Upper Bound	29.36	
		5% Trimmed Mean		28.16	
		Median		25.00	
		Variance		57.030	
		Std. Deviation		7.552	
		Minimum		18	
		Maximum		41	
		Range		23	
		Interquartile Range		10	
		Skewness		.388	.174
		Kurtosis		-1.071	.346
Post-Test Score	Male	Mean		37.75	.413
		95% Confidence Interval for Mean	Lower Bound	36.94	
			Upper Bound	38.57	
		5% Trimmed Mean		37.95	
		Median		39.00	
		Variance		39.554	
		Std. Deviation		6.289	
		Minimum		20	
		Maximum		49	
		Range		29	
		Interquartile Range		7	
		Skewness		-.429	.160
		Kurtosis		-.263	.318
	Female	Mean		37.80	.470

	95% Confidence Interval for Mean	Lower Bound	36.88	
		Upper Bound	38.73	
	5% Trimmed Mean		37.90	
	Median		39.00	
	Variance		43.206	
	Std. Deviation		6.573	
	Minimum		20	
	Maximum		49	
	Range		29	
	Interquartile Range		10	
	Skewness		-.201	.174
	Kurtosis		-.677	.346

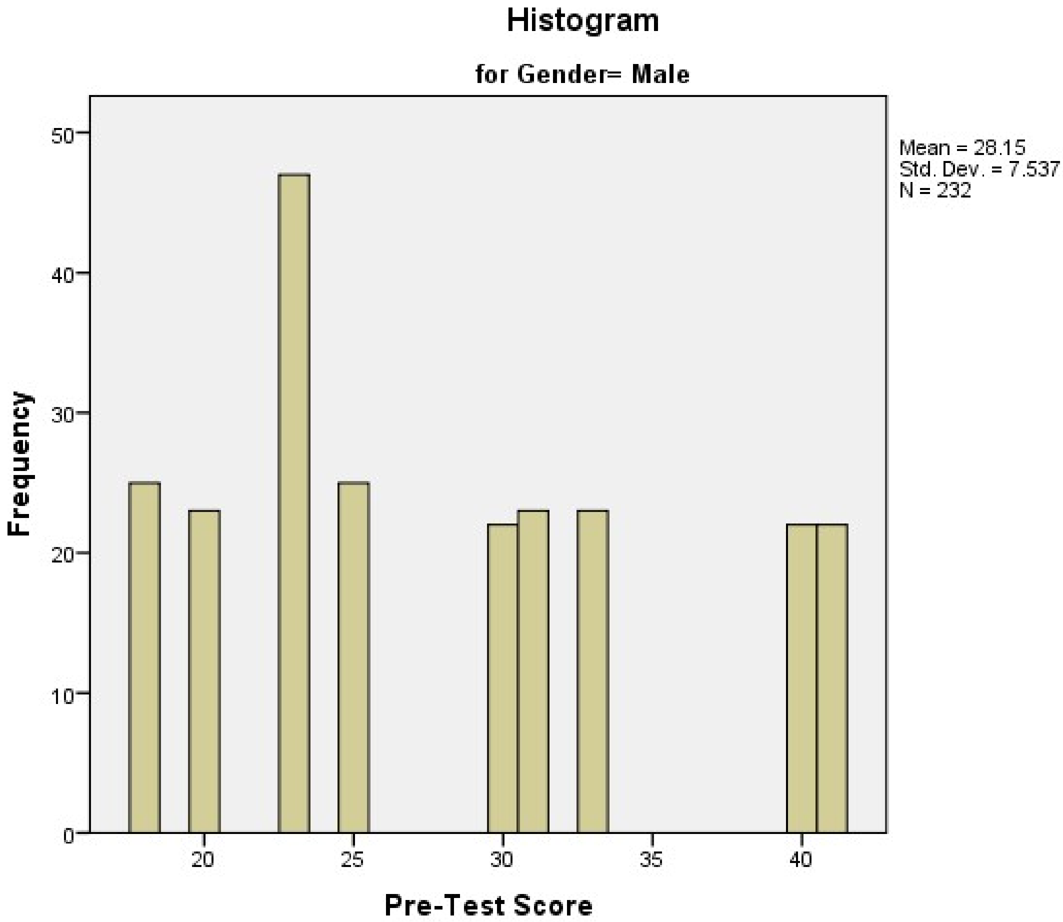
Tests of Normality

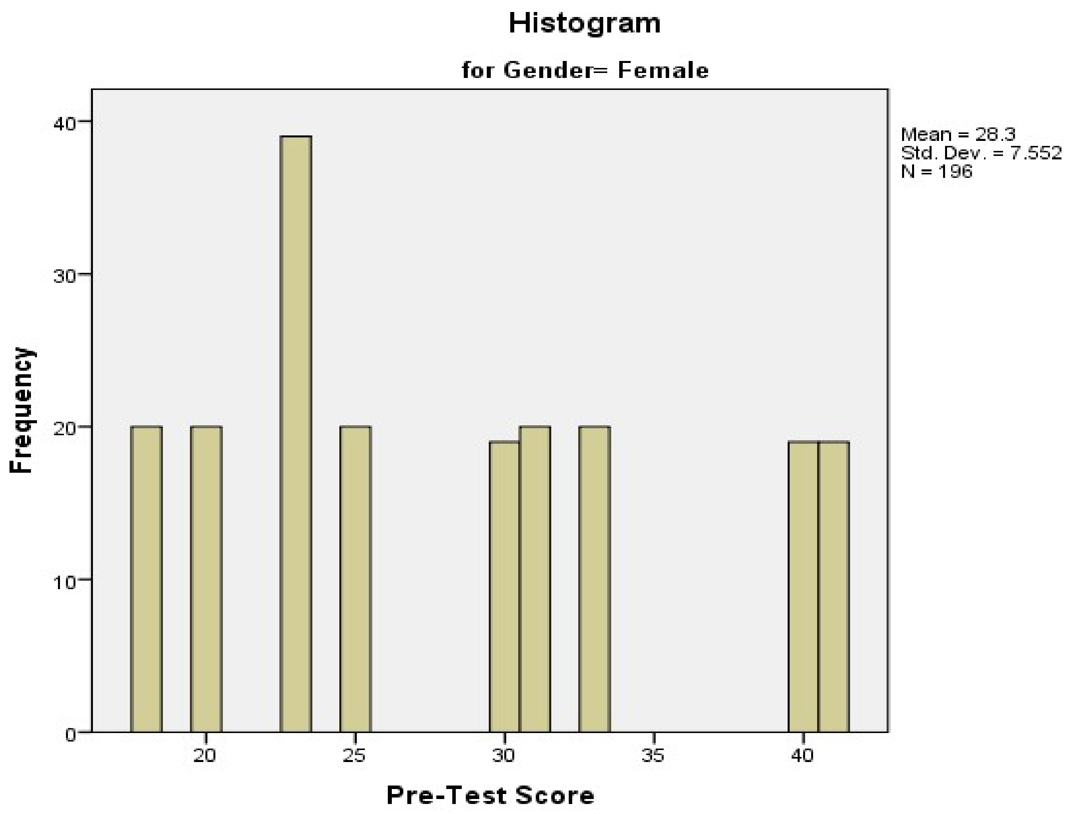
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Gender	Statistic	df	Sig.	Statistic	df	Sig.
Pre-Test Score	Male	.179	232	.000	.898	232	.000
	Female	.174	196	.000	.900	196	.000
Post-Test Score	Male	.105	232	.000	.970	232	.000
	Female	.123	196	.000	.955	196	.000

a. Lilliefors Significance Correction

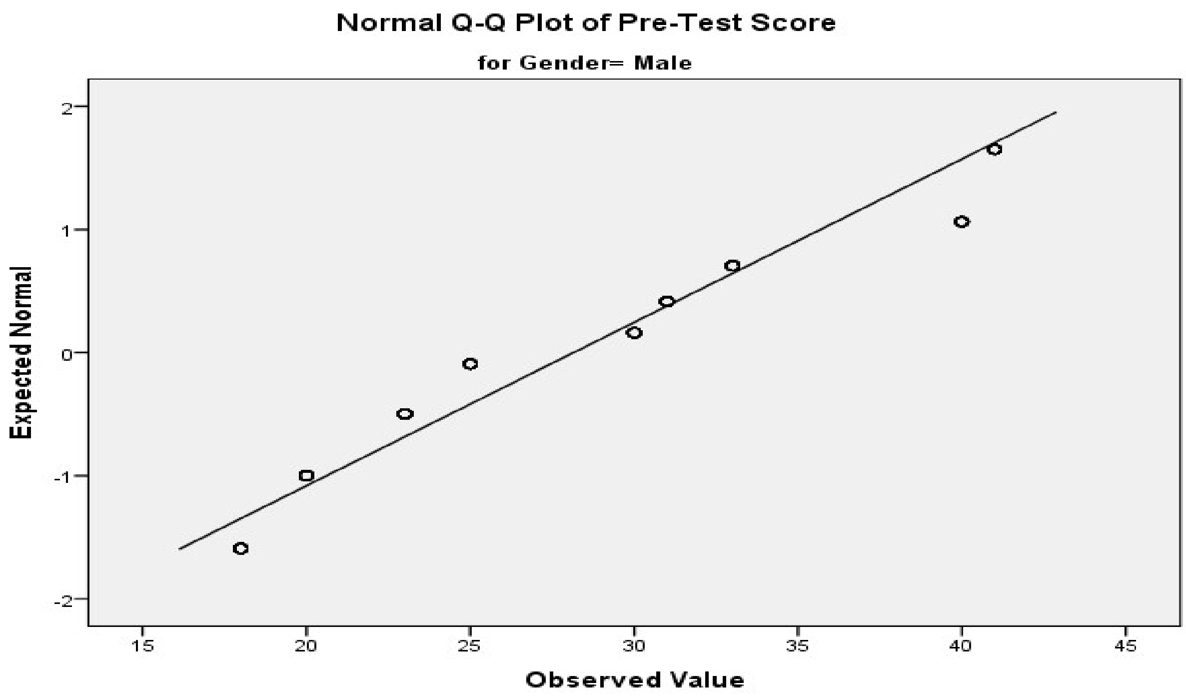
Pre-Test Score

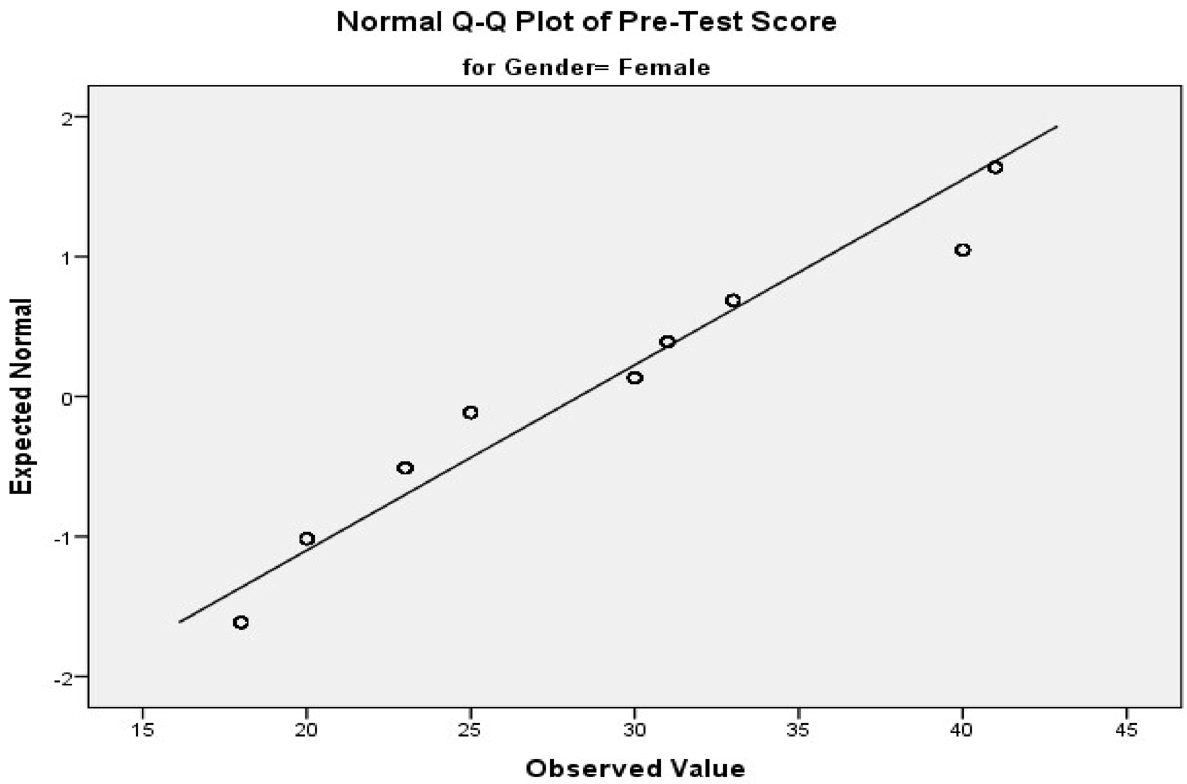
Histograms


Histogram
for Gender= Male
Mean = 28.15
Std. Dev. = 7.537
N = 232
Frequency
0
10
20
30
40
50
20
25
30
35
40
Pre-Test Score

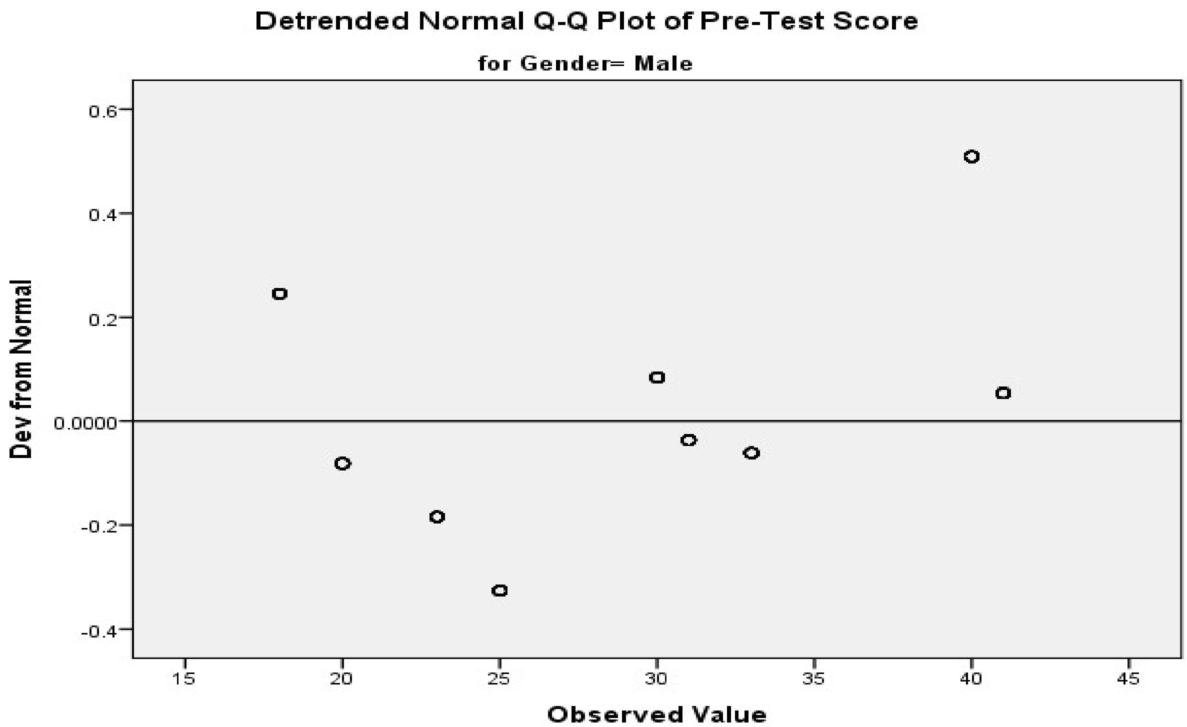


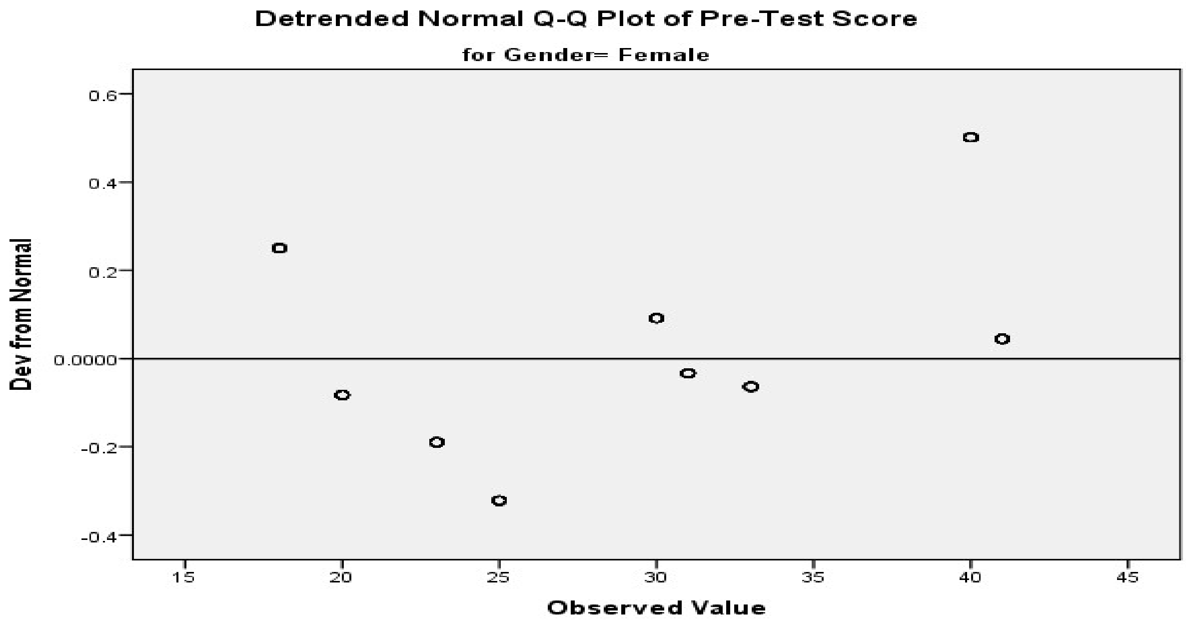
Normal Q-Q Plots

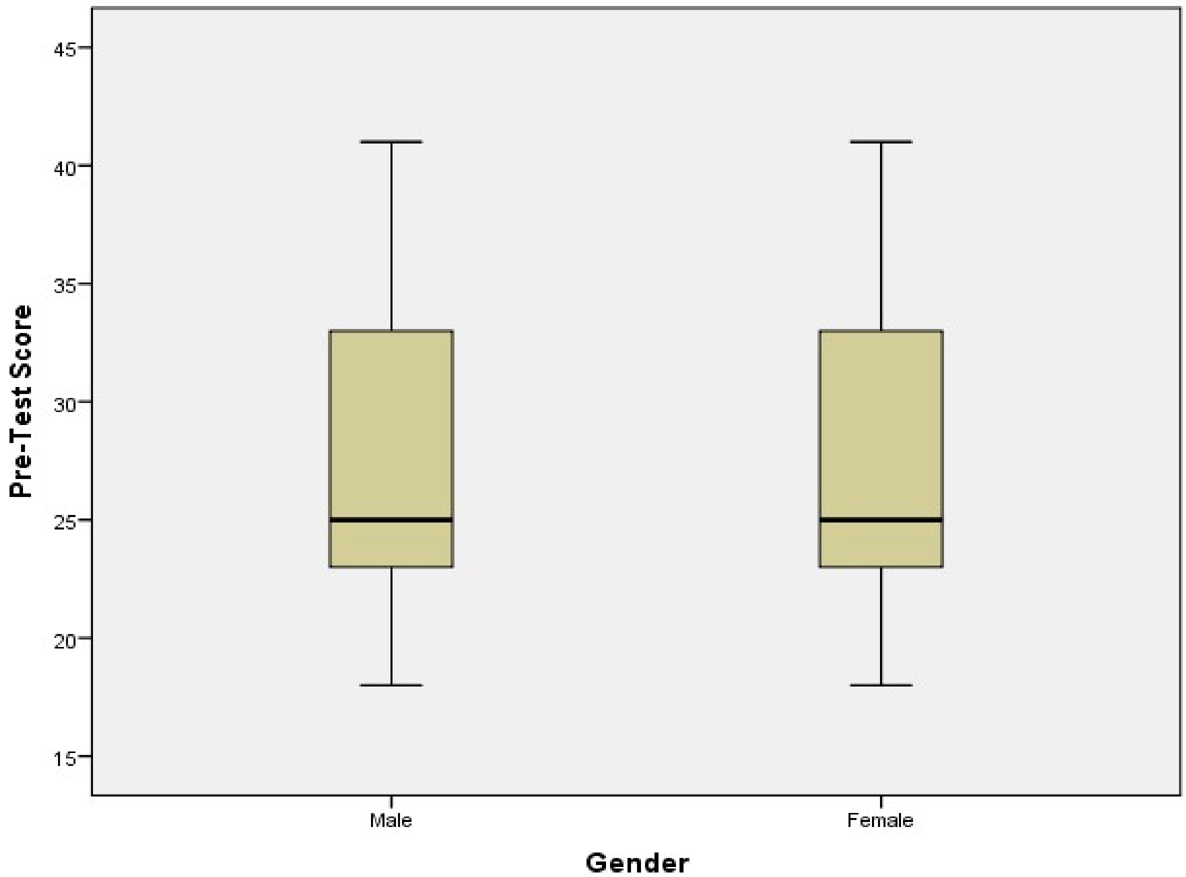




Detrended Normal Q-Q Plots

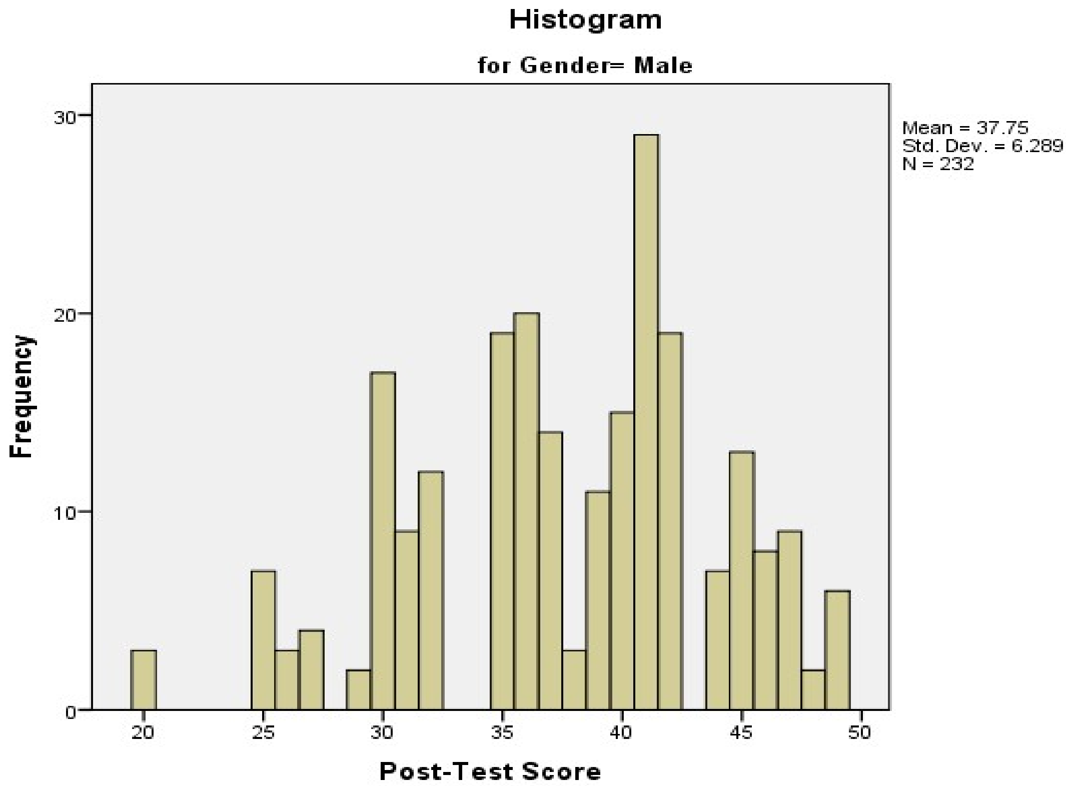


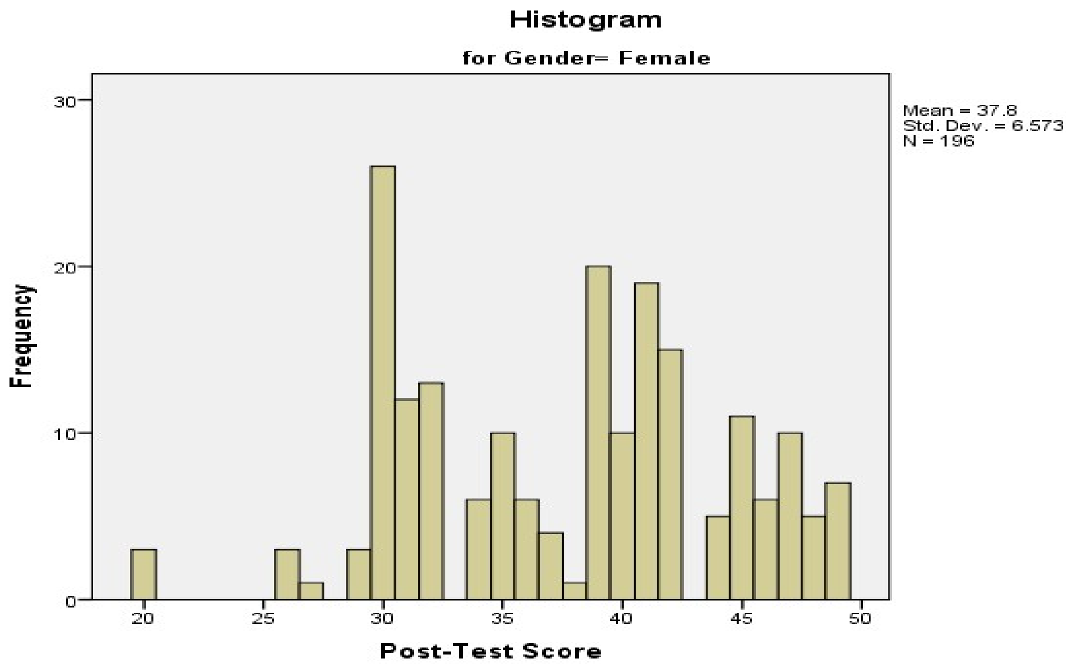

Detrended Normal Q-Q Plot of Pre-Test Score
for Gender= Female
Dev from Normal
Observed Value
0.6
0.4
0.2
0.0000
-0.2
-0.4
15
20
25
30
35
40
45


Pre-Test Score
Gender
Male
Female
45
40
35
30
25
20
15

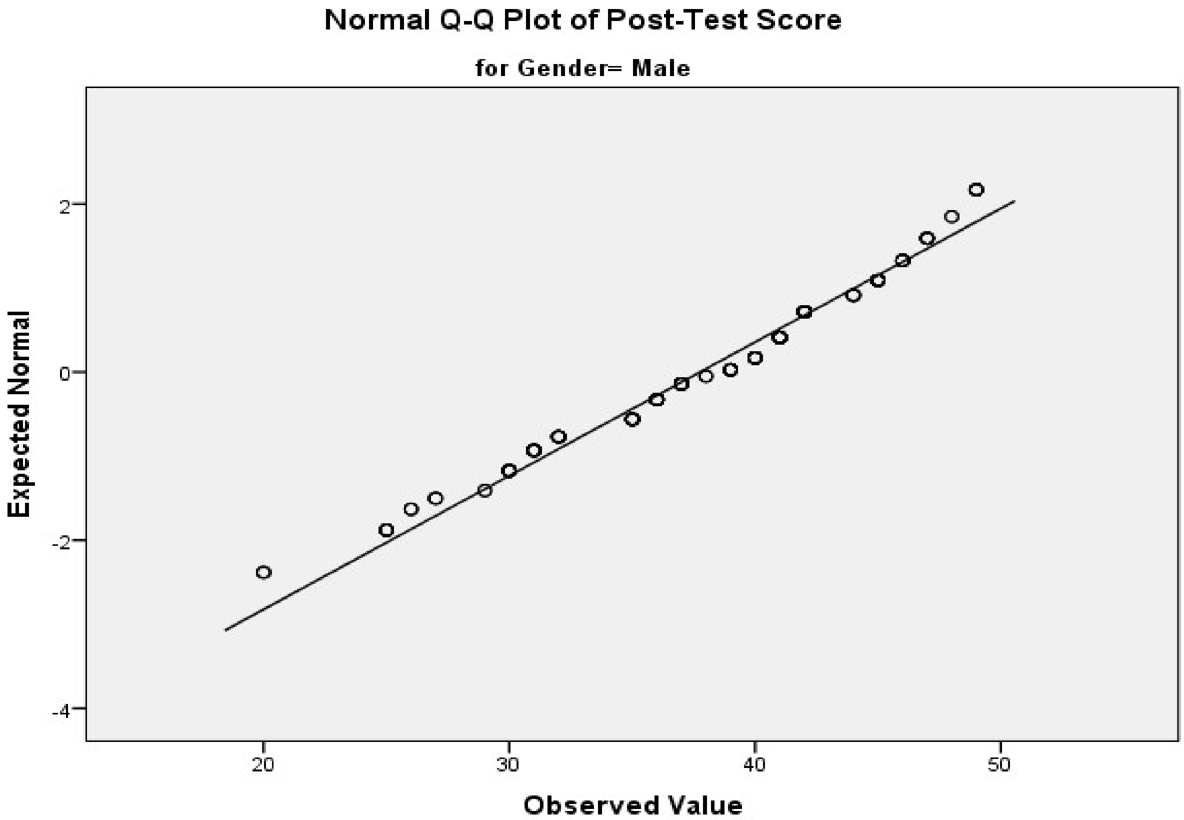
Post-Test Score

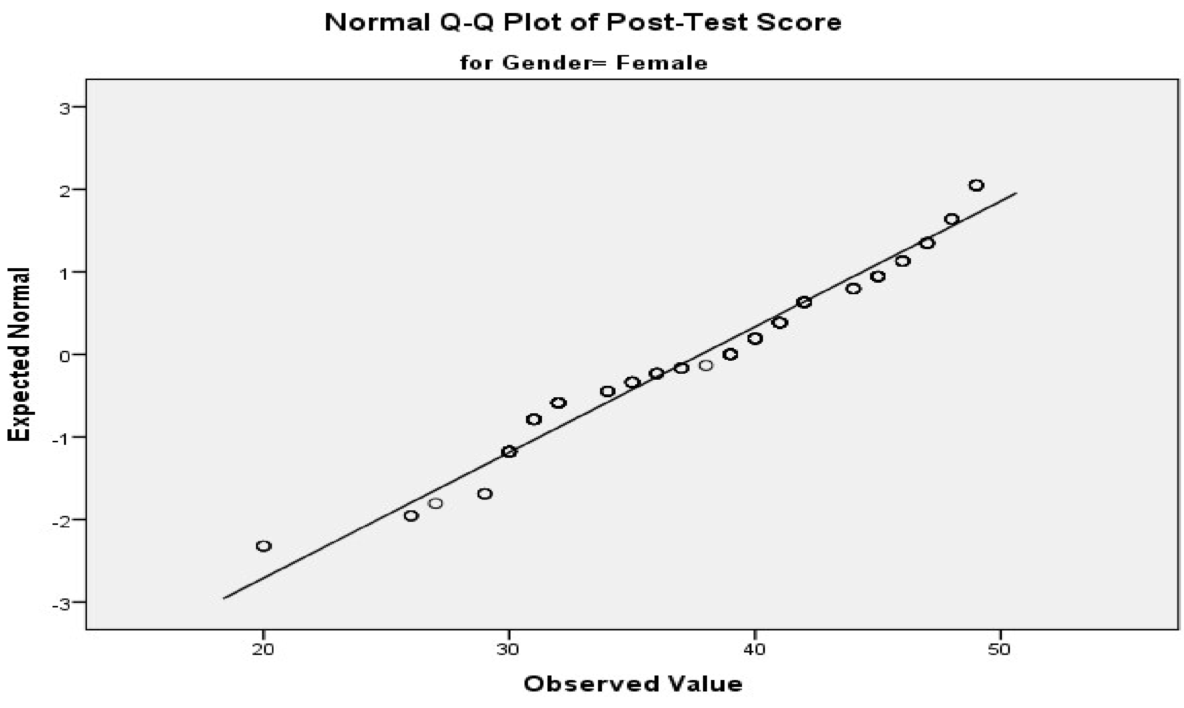
Histograms



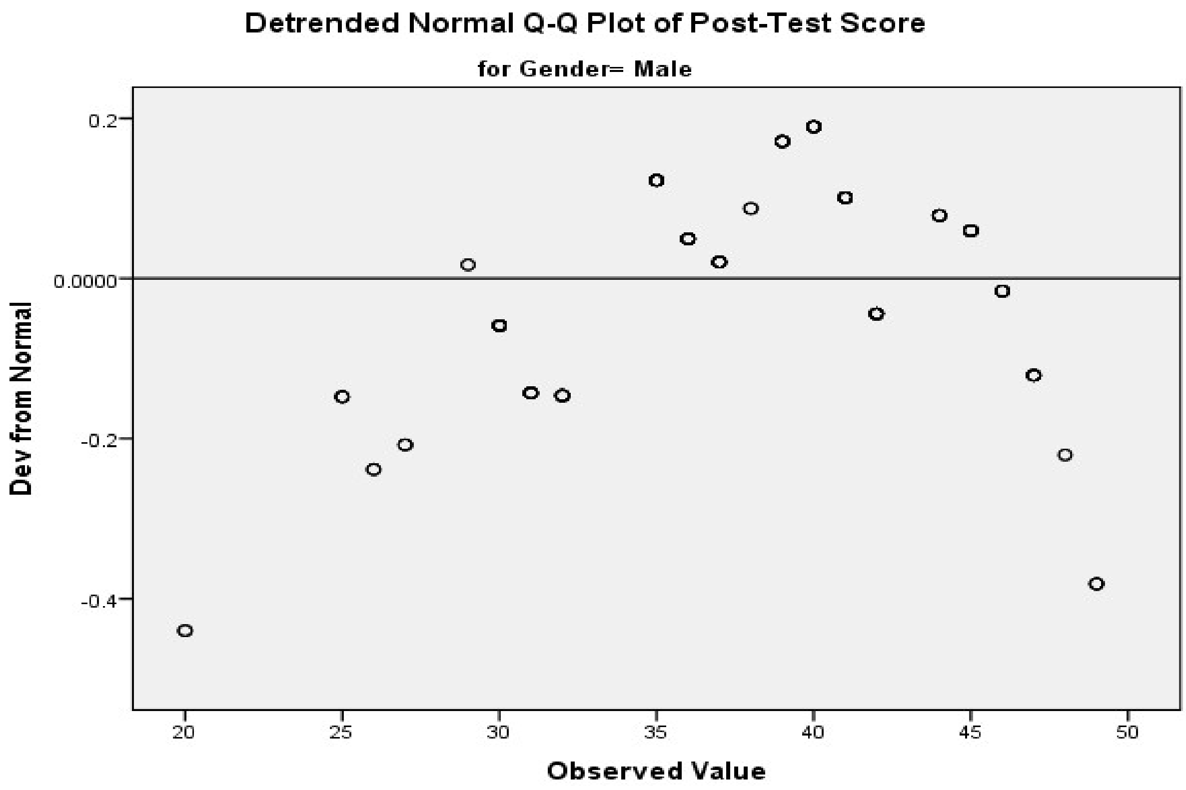


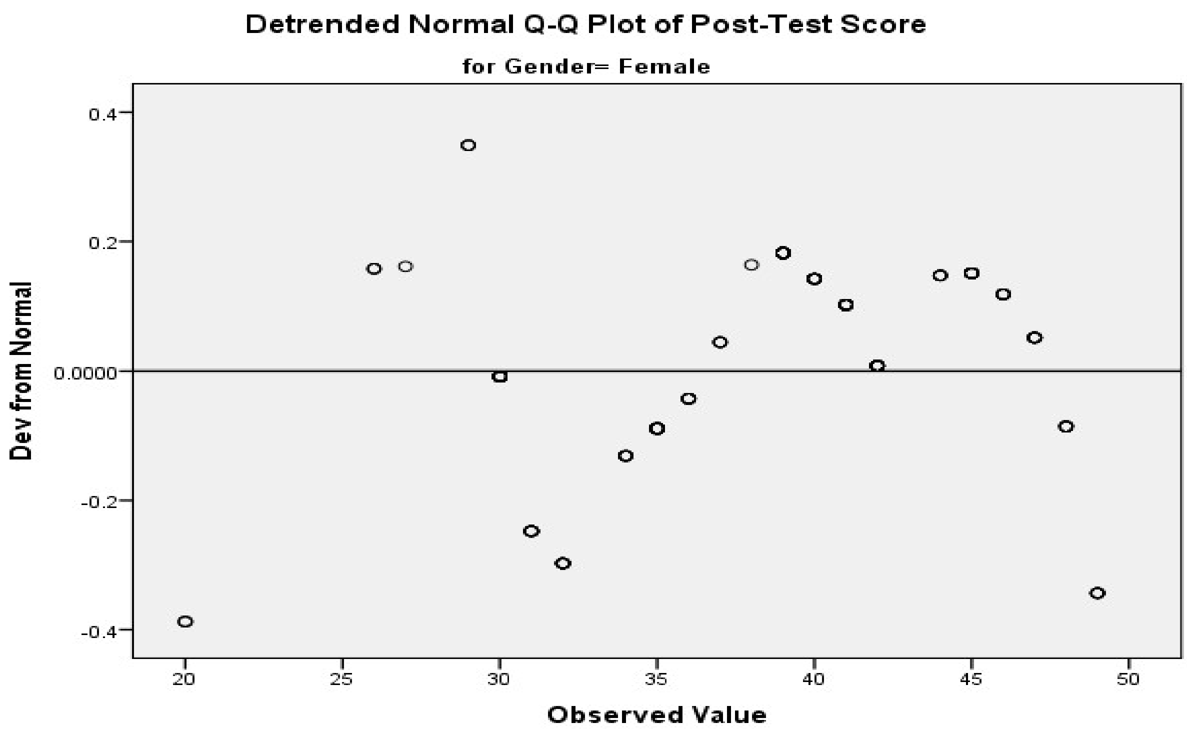
Normal Q-Q Plots

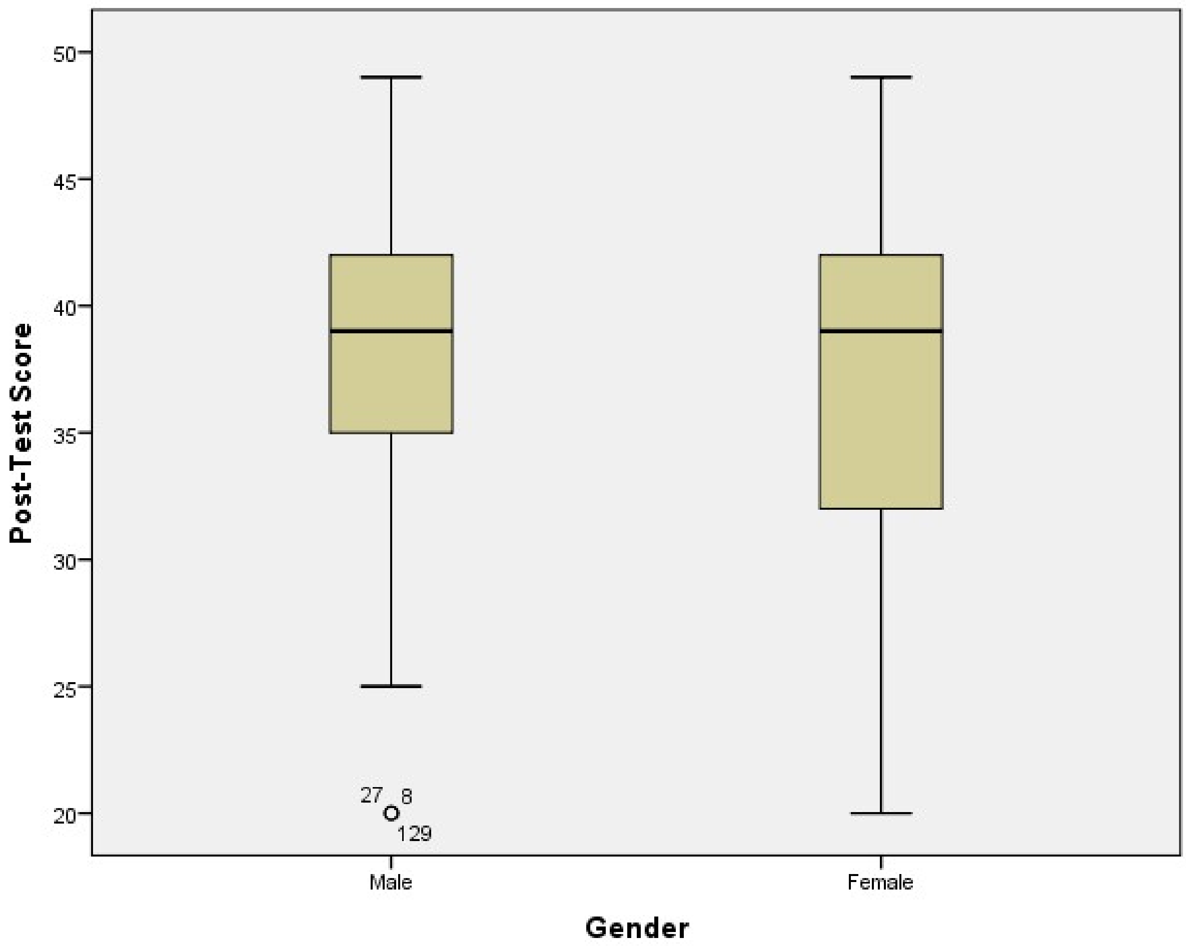




Detrended Normal Q-Q Plots






50
45
40
35
30
25
20
Post-Test Score
27
8
129
Male
Female
Gender

Group

Case Processing Summary

	Group	Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Pre-Test Score	Experimental	229	100.0%	0	0.0%	229	100.0%
	Control	199	100.0%	0	0.0%	199	100.0%
Post-Test Score	Experimental	229	100.0%	0	0.0%	229	100.0%
	Control	199	100.0%	0	0.0%	199	100.0%

Descriptives

	Group			Statistic	Std. Error
Pre-Test Score	Experimental	Mean		28.23	.499
		95% Confidence Interval for Mean	Lower Bound	27.24	
			Upper Bound	29.21	
		5% Trimmed Mean		28.09	
		Median		25.00	
		Variance		56.939	
		Std. Deviation		7.546	
		Minimum		18	
		Maximum		41	
		Range		23	
		Interquartile Range		10	
		Skewness		.402	.161
		Kurtosis		-1.059	.320
	Control	Mean		28.20	.535

		95% Confidence Interval for Mean	Lower Bound	27.15	
			Upper Bound	29.26	
		5% Trimmed Mean		28.06	
		Median		25.00	
		Variance		56.889	
		Std. Deviation		7.542	
		Minimum		18	
		Maximum		41	
		Range		23	
		Interquartile Range		10	
		Skewness		.406	.172
		Kurtosis		-1.052	.343
Post-Test Score	Experimental	Mean		42.43	.250
		95% Confidence Interval for Mean	Lower Bound	41.93	
			Upper Bound	42.92	
		5% Trimmed Mean		42.59	
		Median		42.00	
		Variance		14.351	
		Std. Deviation		3.788	
		Minimum		30	
		Maximum		49	
		Range		19	
		Interquartile Range		5	
		Skewness		-.483	.161
		Kurtosis		.858	.320

	Control	Mean		32.42	.304
		95% Confidence Interval for Mean	Lower Bound	31.82	
			Upper Bound	33.02	
		5% Trimmed Mean		32.64	
		Median		32.00	
		Variance		18.336	
		Std. Deviation		4.282	
		Minimum		20	
		Maximum		39	
		Range		19	
		Interquartile Range		6	
		Skewness		-.606	.172
		Kurtosis		.474	.343

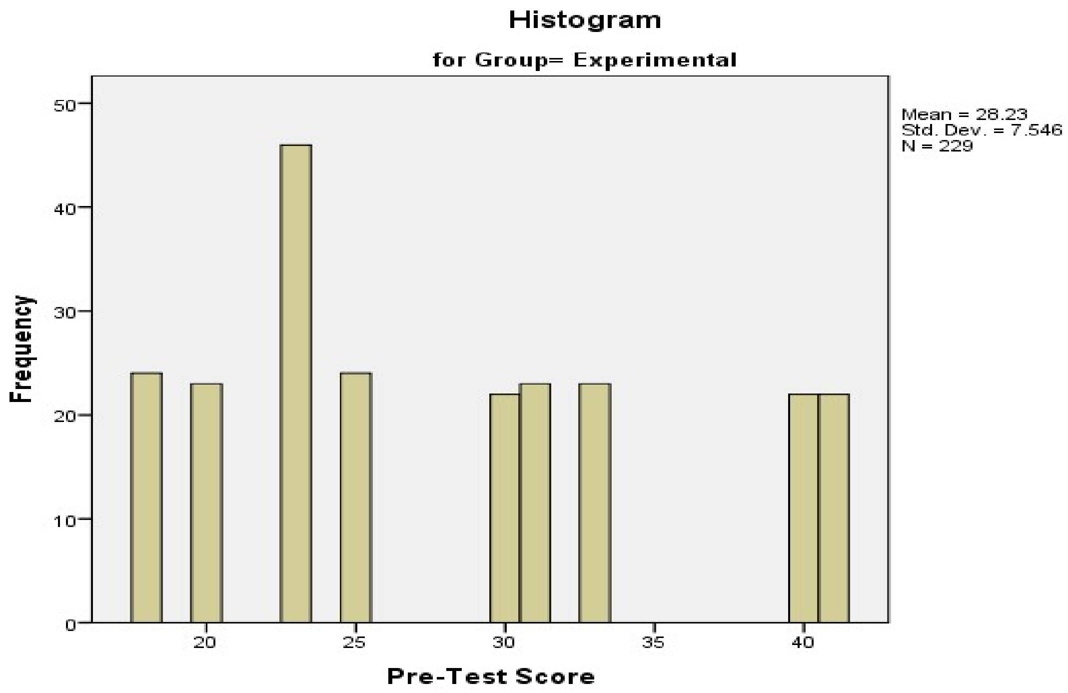
Tests of Normality

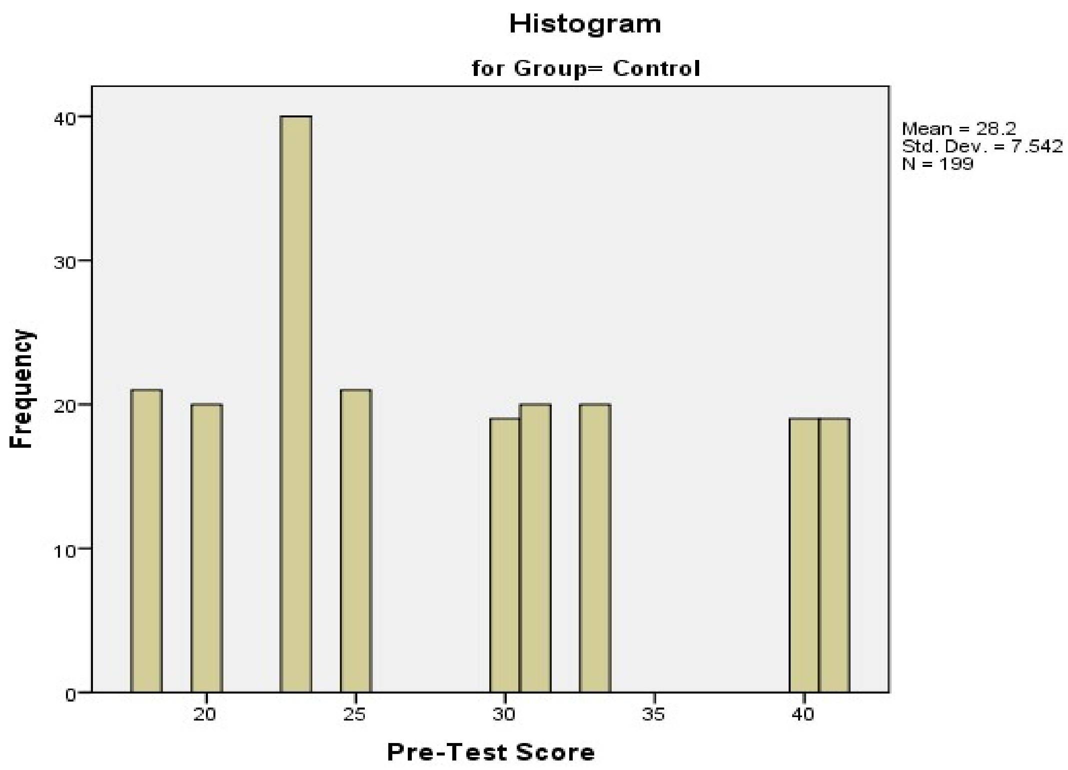
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Group	Statistic	df	Sig.	Statistic	df	Sig.
Pre-Test Score	Experimental	.176	229	.000	.899	229	.000
	Control	.177	199	.000	.899	199	.000
Post-Test Score	Experimental	.156	229	.000	.942	229	.000
	Control	.140	199	.000	.936	199	.000

a. Lilliefors Significance Correction

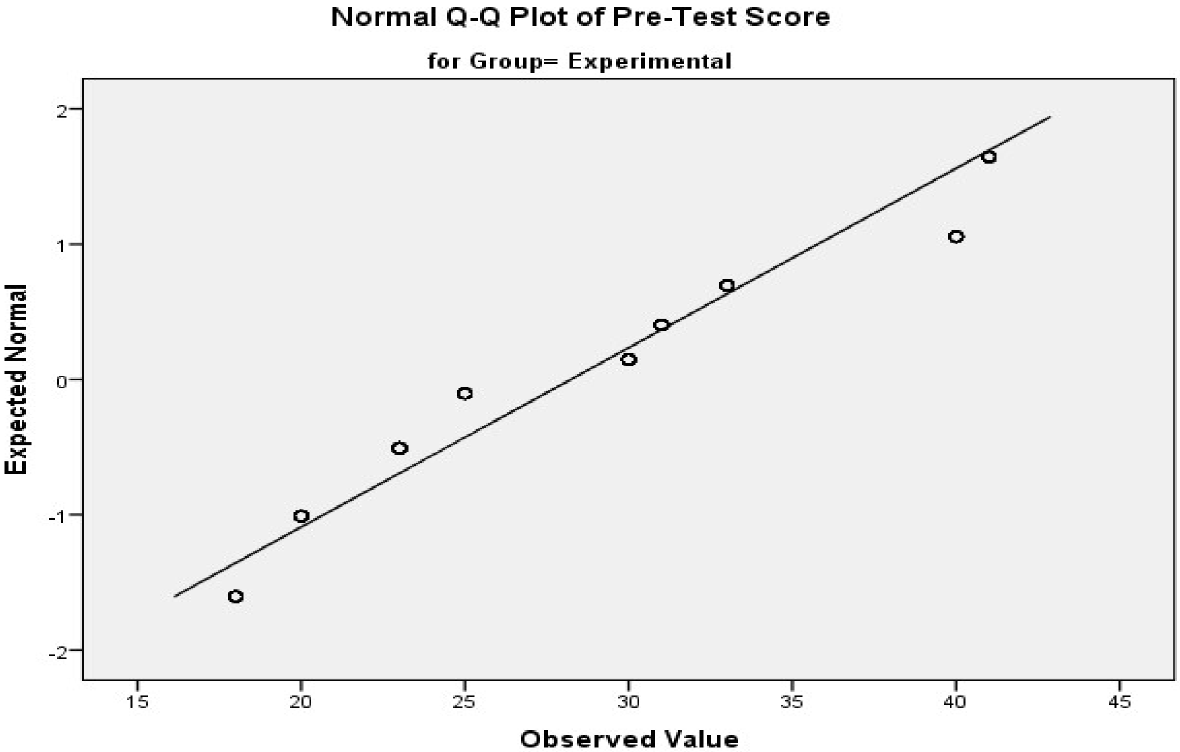
Pre-Test Score

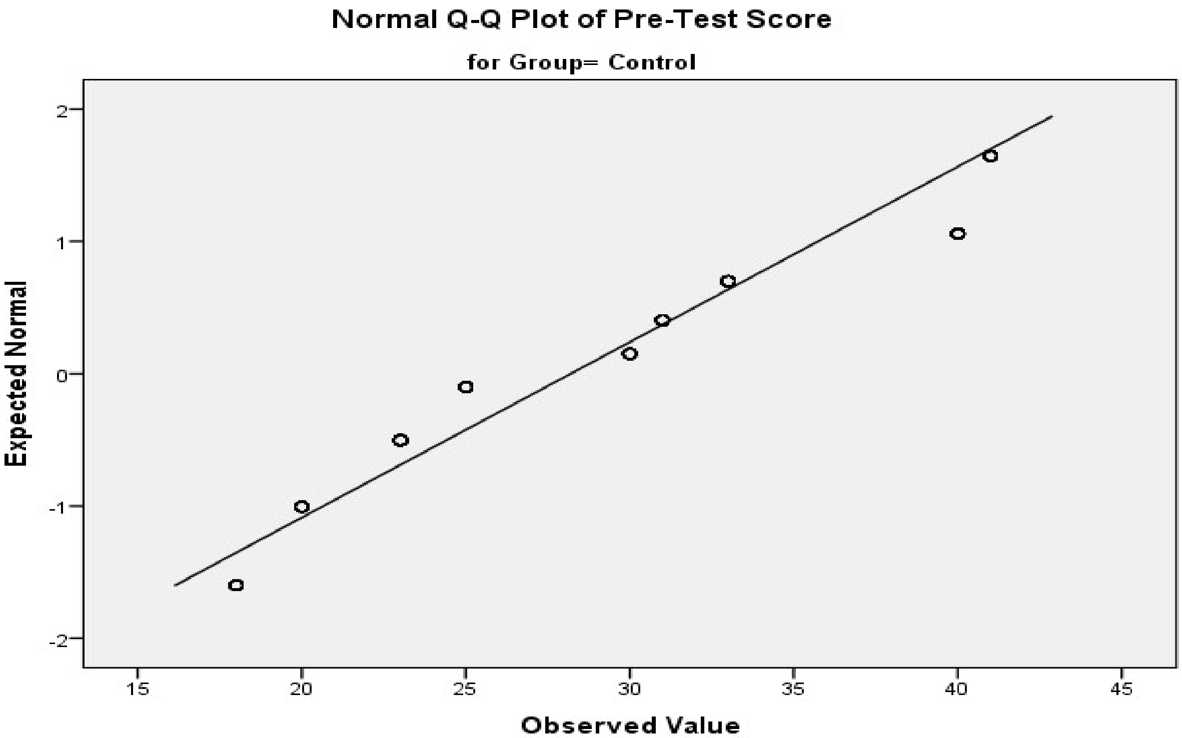
Histograms



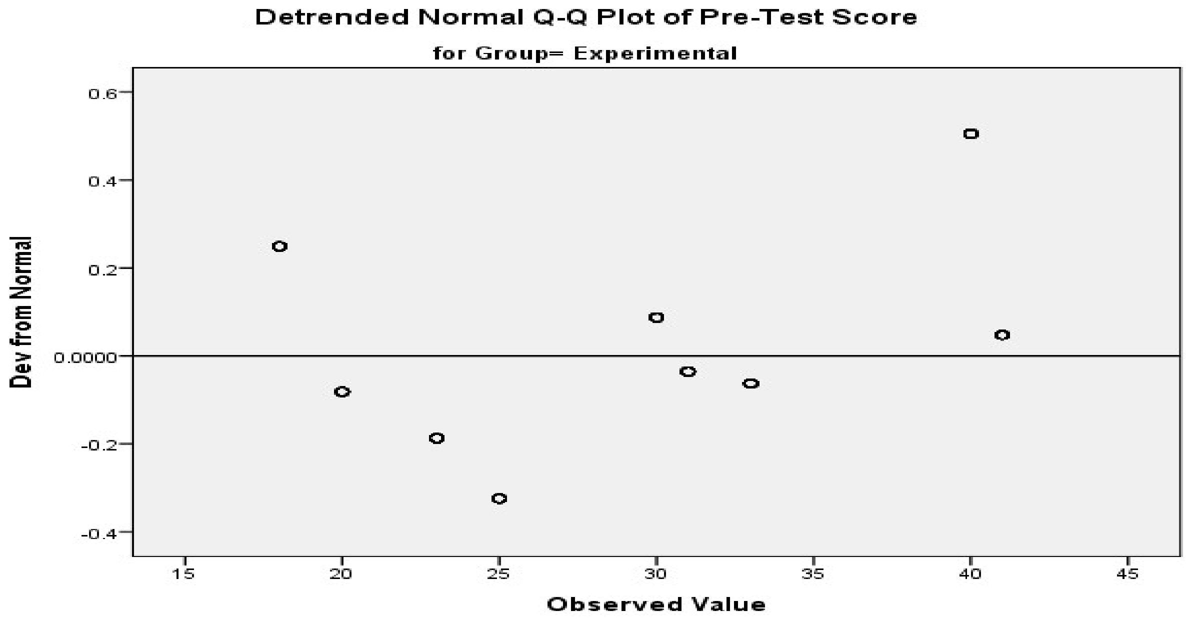


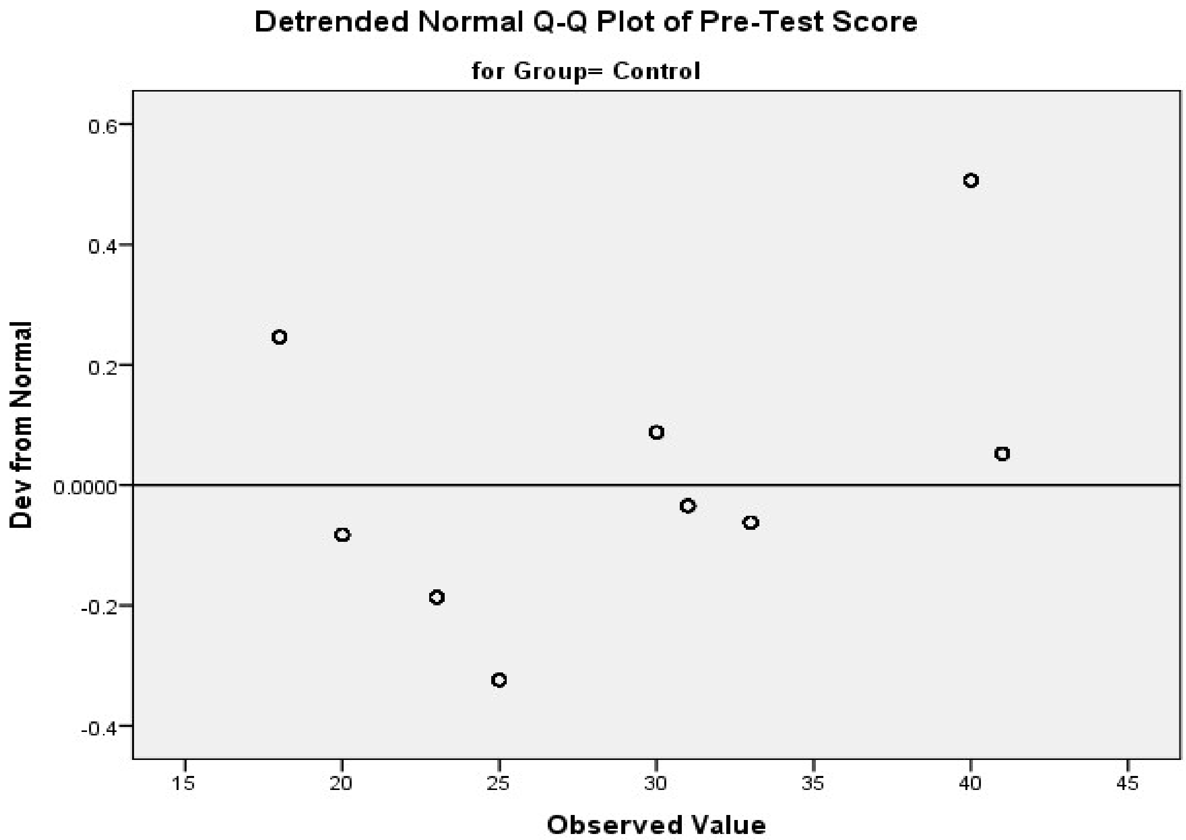
Normal Q-Q Plots



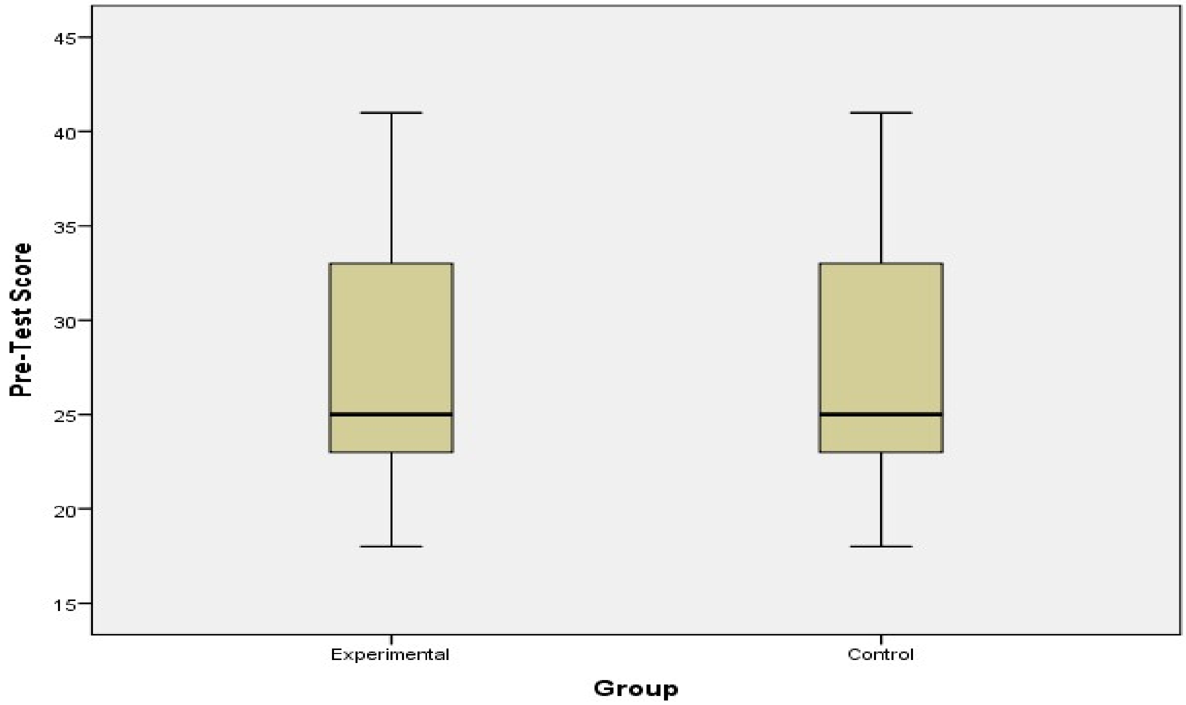


Detrended Normal Q-Q Plots



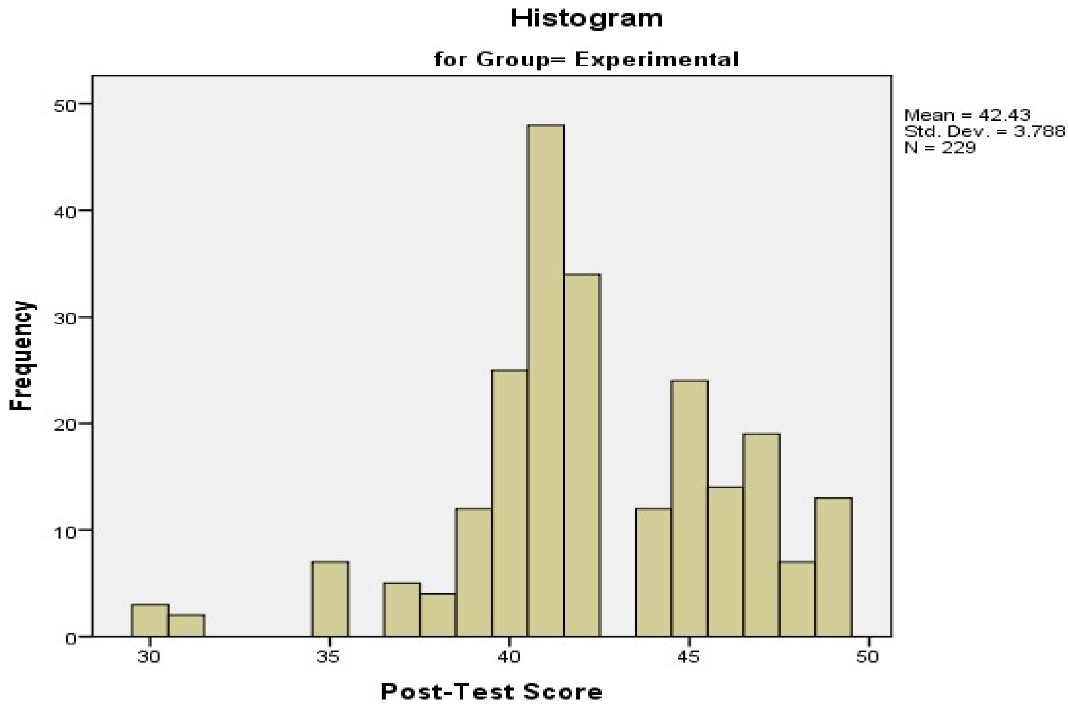


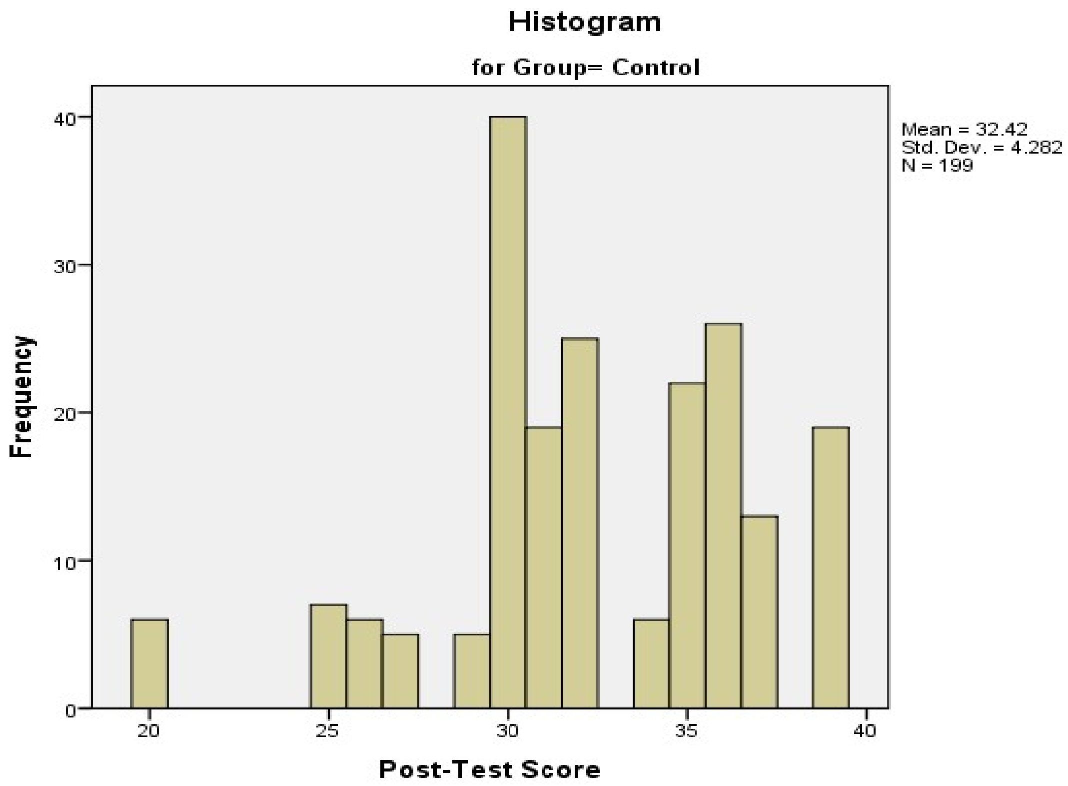
Boxplots



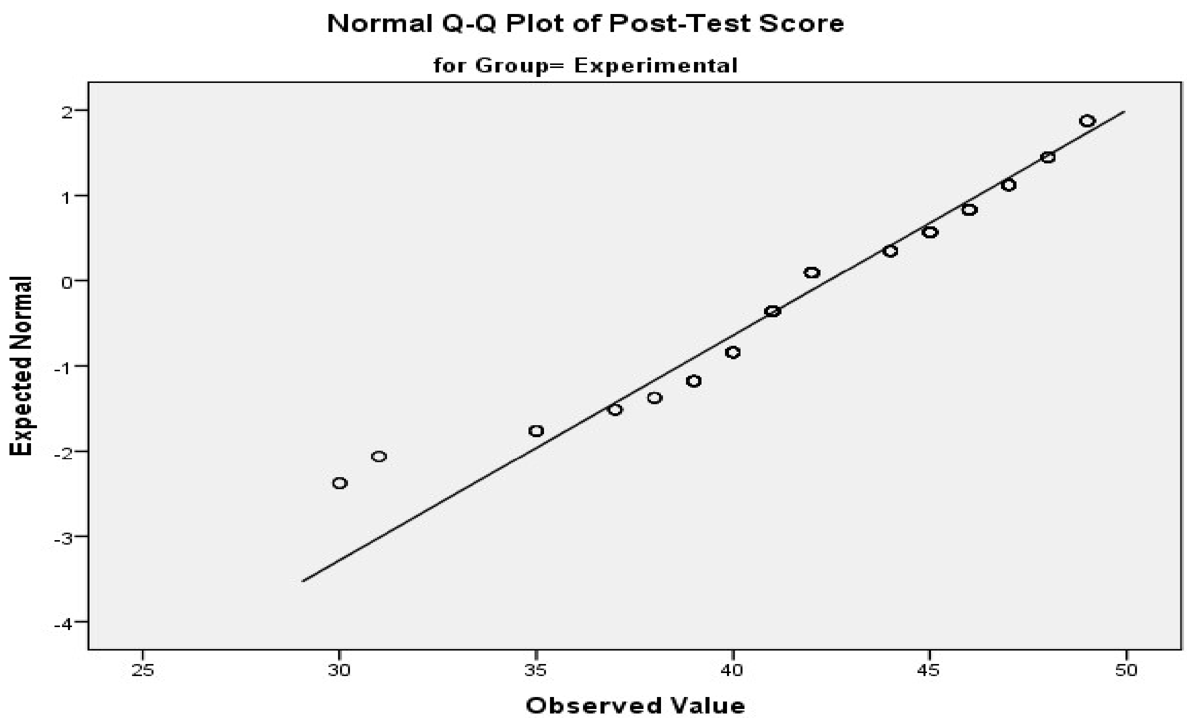
Post-Test Score

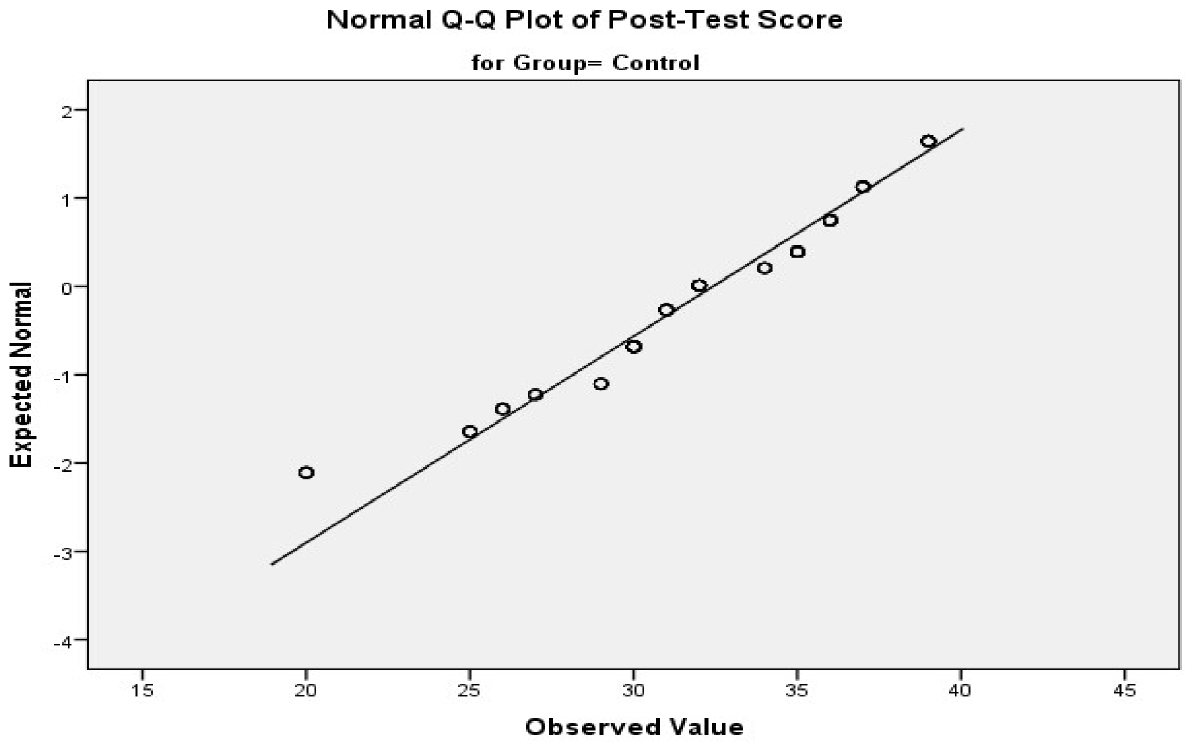
Histograms



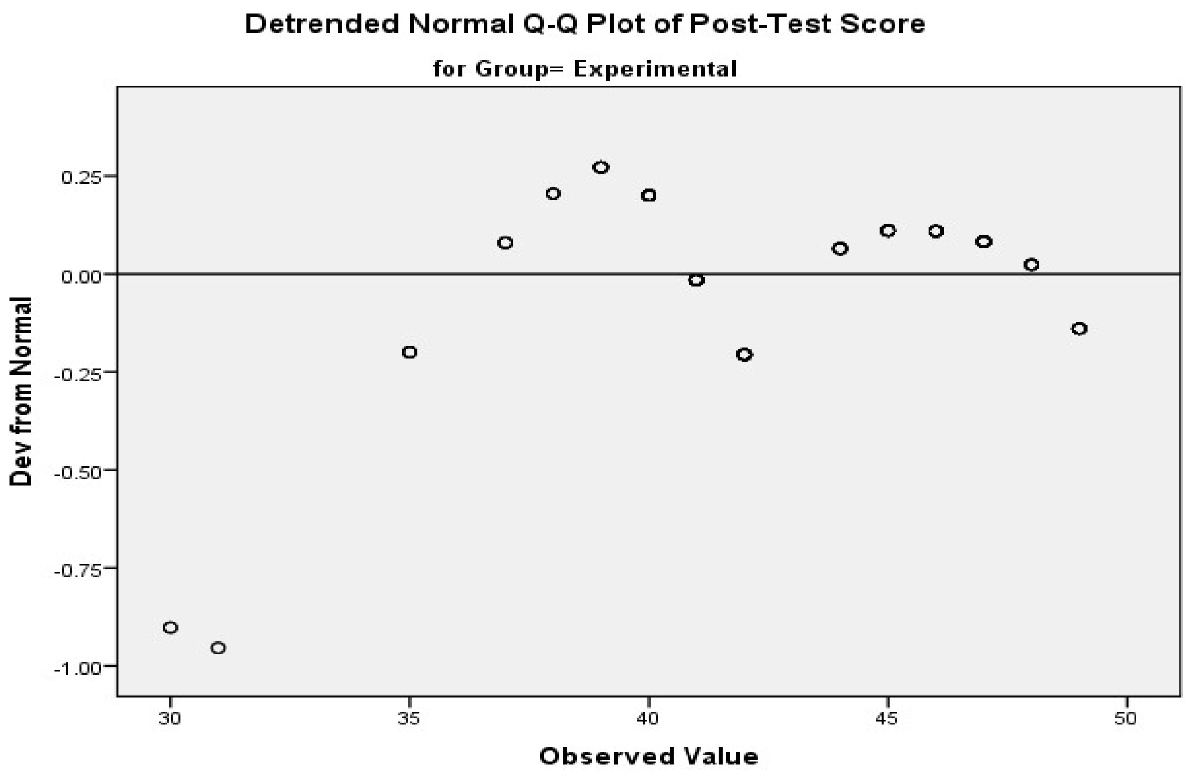


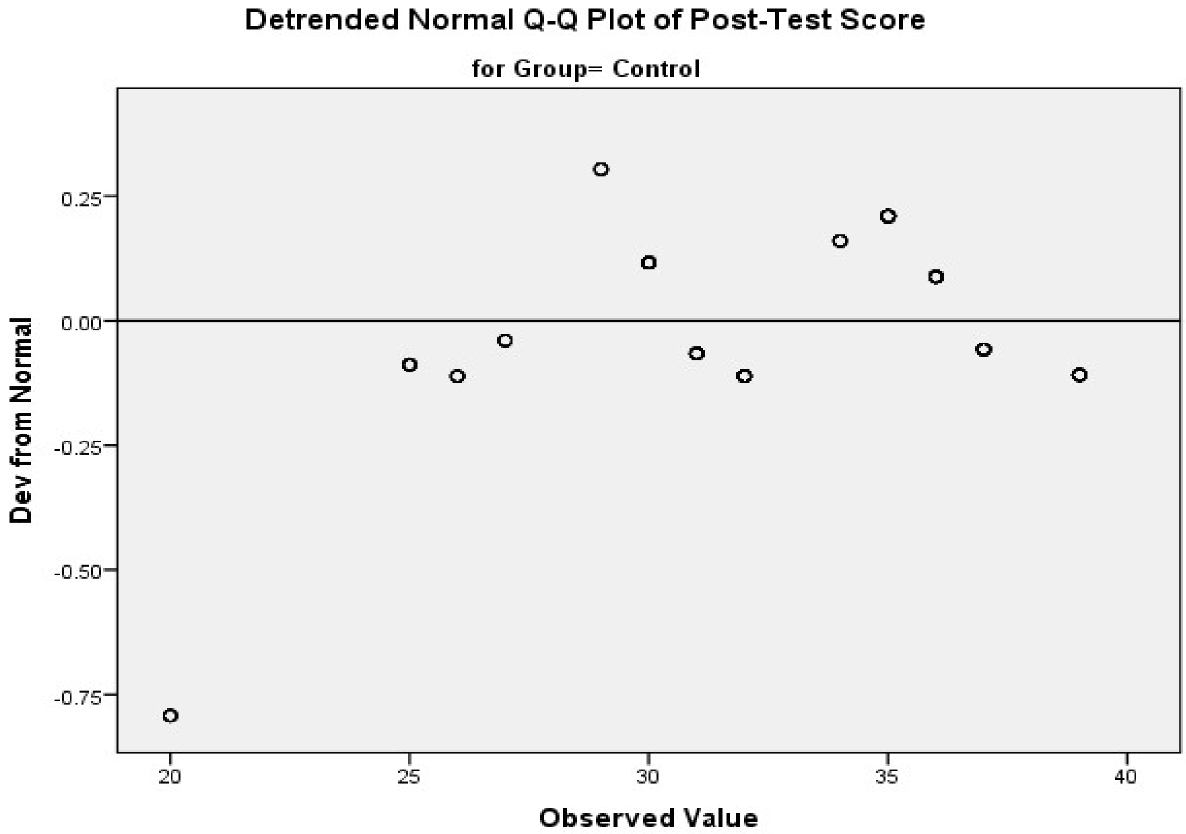
Normal Q-Q Plots



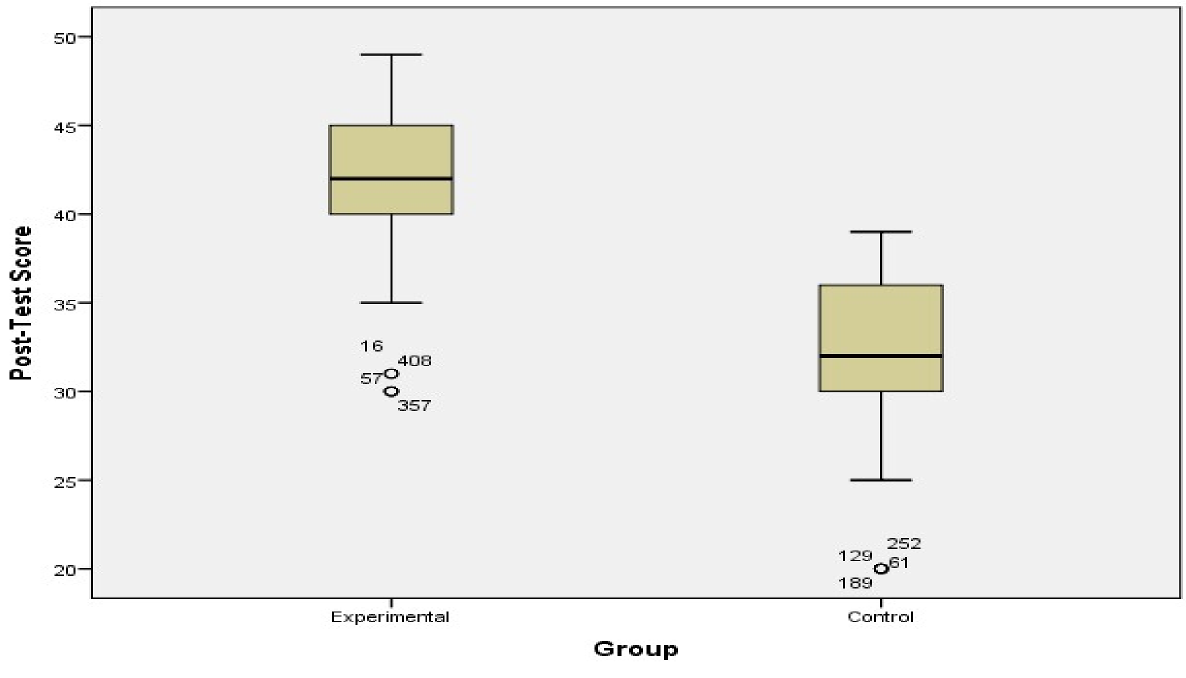


Detrended Normal Q-Q Plots




Detrended Normal Q-Q Plot of Post-Test Score
for Group= Control
Dev from Normal
0.25
0.00
-0.25
-0.50
-0.75
20
25
30
35
40
Observed Value

Boxplots


Post-Test Score
50
45
40
35
30
25
20
16
408
57
357
252
129
61
189
Experimental
Control
Group

APPENDIX VI

TEST OF HOMOGENEITY OF VARIANCE

This test was used to check if our samples are optioned from populations of equal variance. This means that the variability of scores for each of our groups is similar. This will be done using Levene Test of Equality of Variances. The result is shown below:

Hypothesis 2

		Levene's Test for Equality of Variances	
		F	Sig.
Chemistry	Equal variances assumed Equal variances not assumed	.076	.783

Hypothesis 3

		Levene's Test for Equality of Variances	
		F	Sig.
chemistry achievement of Students Taught with the 5E learning cycle	Equal variances assumed Equal variances not assumed	.404	.529

Hypothesis 4

		Levene's Test for Equality of Variances	
		F	Sig.
chemistry achievement of Students Taught with the 5E learning cycle	Equal variances assumed Equal variances not assumed	2.286	.139

Hypothesis 5

Levene's Test of Equality of Error Variances[a]

Dependent Variable: Post-Test Score

F	df1	df2	Sig.
.032	3	76	.992

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Pre_Test + Group + Gender + Group * Gender

APPENDIX VII

TEST OF LINEAR REGRESSION AND HOMOGENEITY OF REGRESSION SLOPES

While the Linear Regression Test will be used to test for linear relationship between our dependent variable and covariate, the Homogeneity of Regression Slopes Test will be used to test whether the relationship between our covariate and dependent variable for each of our groups is the same. Both tests were conducted using a scatterplots. The result is shown below: