IMPACT OF INQUIRY-BASED INSTRUCTION ON SELF-EFFICACY AND UNDERSTANDING OF NATURE OF SCIENCE AMONG NCE BIOLOGY STUDENTS IN LAFIAGI, KWARA STATE, NIGERIA

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DECLARATION

I declare that this dissertation entitled "Impact of Structured Inquiry – Based Instruction on Self- Efficacy and Understanding of Nature of Science among Nigeria Certificate In Education (NCE) Biology Students in Kwara State, Nigeria" has been carried out by the researcher in the Department of Science Education and that it has not been presented in any previous submission for higher degree to the best of my knowledge. In the course of writing this dissertation, references are made to several of information. This was fully acknowledged by means of reference.

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CERTIFICATION

This dissertation entitled "Impact of Structured Inquiry- Based Instruction on Self Efficacy and Understanding of Nature of Science among Nigeria Certificate In Education (NCE) Biology Student in Kwara State" by Musa DANGANA P13EDSC8038 meets the regulation governing the award of the degree of master of science education of Ahmad Bello university Zaria and is approved for it contribution to knowledge and literary presentation.

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DEDICATION

This dissertation is dedicated to my late father Alhaji A.Y. Dangana, my mother Hajjiya Mariam Jumai Dangana, my step mum Mallama Hassana Mamman Dangana and my siblings, most especially Mal. Baba Dangana and Mal. Lawal Aliyu Dangana for their love and support throughout the period of my study.

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LIST OF ABBREVIATIONS

In the course of this study some words have been abbreviated and frequently used in the text. The abbreviated words include:

ABU:	Ahmadu Bello University
NCE:	Nigeria Certificate in Education
NOSAT:	Nature of Science Understanding Test
NOSSET:	Nature of Science Self Efficiency Test
STAN:	Science Teachers Association of Nigeria
NUT:	National Union of Teachers
TRCN:	Teachers Registration Council of Nigeria
E.G:	Experimental Group
C.G:	Control Group
FME:	Federal Ministry Education
NCCE:	National Commission for Colleges of Education
AAAS:	American Association for the Advancement of Science
NPE:	National Policy on Education
PPMCC:	Pearson Product- Moment Correlation Coefficient.

OPERATIONAL DEFINITION OF TERMS

Structured Inquiry Based Instruction: this refers to a teaching approach by which concept are taught by giving the students' problem and procedures but not the outcome.

Lecture Method: this refers to a teaching approach by which concept were taught to the students verbally using chalk and board.

Self- Efficiency as a concept refers to being able to picture one-self achieving what one want to achieve at the level needed to achieved. This is the belief a leaner has that he can accomplish a task successfully.

Nature of Science Understanding Test (NASUT): this is an assessment tool adapted by the researcher which was used to measure understanding of nature of science in cell biology concept.

ABSTRACT

This study is to investigate the Impact of Inquiry-Based Instruction on Self-efficacy and Understanding of Nature of Science among NCE Biology Students. There are four research questions and four null hypotheses. The research design for the study was quasi experimental which adopted the pretest-posttest experimental control groups design. The population for the study comprises of all the NCE1biology students of three State Colleges of Education in Kwara State with the population of two thousand two hundred and seven. The sample consisted of ninety NCE1 biology students that were drawn from two colleges of education, forty five from each college, from the two colleges of education from the population of one thousand four hundred and sixty seven using table of randomization. The students were randomly assigned to experimental and control groups. The experimental groups were taught cell biology using inquiry-based instruction while the control groups were taught cell biology using lecture method. A pre-test using Nature of Science Understanding Test (NOSUT) and Nature of Science Self-efficacy Questionnaire (NOSSEQ) was administered to the Inquiry-based instruction group and Lecture method group respectively to determine their entry level in understanding of nature of science before treatment. NOSUT and NOSSEQ were administered as post-test to both the Inquiry and Lecture method groups to find out the impact of the treatment. The two instruments used for data collection, (NOSUT & NOSSEQ) have the reliability of 0.96 & 0.79 respectively. The data obtain was used in analyzing the research question and the hypotheses stated was subjected to test using t-test statistics at 0.05 level of significance, while Pearson Product Moment Correlation Coefficient (PPMC) was used in determining the relationship between the groups. From the result obtained the hypothesis one, two and four were rejected while hypothesis three was retained. The summary of the findings revealed that understanding of nature of science and student's self-efficacy was enhanced through exposure to inquiry instruction. Base on the findings: The structured inquiry-based instruction is very effective in enhancing self-efficacy and understanding of nature of science by NCE students. Lecturers should employ structured inquiry-based instruction in teaching cell biology concepts so as to improve students' self-efficacy and understanding of nature of science in cell biology.

CHAPTER ONE

THE PROBLEM

1.1 Introduction

Science, as a discipline has received tremendous support across the globe, particularly by Nigerian Government after independence in 1960. Statement of the government intentions and input was documented in National Policy on Education (2004) which emphasized the need to maintain high level of scientific literacy, make science compulsory in primary, secondary and tertiary institutions. In effect, the Nigerian child is exposed to science learning throughout the three levels of education (Isaiah, 2010). The essence of learning science at the various levels of education is to develop and improve the society scientific literacy.This can only be achieved when the students understand the nature of science which has to deal with the individual knowledge construction through hands-on and minds-on activities

In the Nigeria's philosophy of education, it was stated that education is an instrument for national development, and the instrument of persons and ideas are all aspects of education. For a nation to develop, her citizens must acquire scientific literacy through intensive pursue of credible science education for all citizens. Across the nation, the importance of science in life is far reaching, not only because we live in an age where every technological discovery and innovation has something to do with science but rather because sciences promote understanding of the world we live in (Abdulrahaman, 2014). To promote the understanding of the world, there is need to understand the nature of science as one of the goals of science teaching in Nigeria (FME, 2004)

There exists a general agreement in the science education community that the major goal of science education is to enhance learners understanding of nature of science (NOS). This goal has been the focus of extensive research efforts for over 50 years (Abd-

El-Khalick & Lederman, 2000; Lederman, 1992). Many reasons have been cited by science education researchers and reform organizations for developing learners' views of NOS, with perhaps the most fundamental reason positing that an understanding of NOS is necessary for achieving scientific literacy (American Association for the Advancement of Science [AAAS], 1990, Tan, 2007).

An informed understanding of nature of science (NOS) is a crucial component of scientific literacy (Bybee, 1997; DeBoer, 1991). To produce a scientifically literate population, the teaching of NOS has to be made an important part of the science curriculum (Rudolph, 2000). The teachers who transform curriculum into practice must have deep understanding of NOS for them to plan activities or learning situations for students to understand the nature of scientific enterprise.

Studies however shows that teachers hold many misconceptions of NOS, and therefore have difficulty in teaching an appropriate view of science to students (Abell & Smith, 1994; Akerson, Abd-El- Khalick,&Lederman, 2000; Lederman, 1992). It has been reported that most elementary school teachers have not heard the term ''nature of science,'' and when they see it in their stated frameworks they misinterpret the term as meaning something to do with nature, not as the essence of science itself. These teachers cannot teach about NOS without first improving their own views (Akerson & Abd-El-Khalick, 2004).

Nature of Science "refers to the characteristics of scientific knowledge that are inherently derived from the manner in which it is produced, that is scientific inquiry (Stephen, & Norman, 2014). Nature of Science involves people's views about how scientific knowledge is constructed. This is often conceptualized as some aspects of the scientific knowledge (Khishfe, 2012), which has already been constructed. Nature of science specifically addresses the beliefs about the nature and construction of knowledge.

As such, NOS involves only one component of the epistemiological beliefs, and that encompasses the beliefs about the nature of knowledge (Khisfe, 2012).

Achieving a scientific literacy requires more than teaching and learning science as a body of knowledge. Rather, it embodies developing scientific literacy which requires a broader view of science that includes three principal components; the knowledge of science, the methods of science, and the nature of science (Randy, Meang & Erin, 2010). To achieve the goal of having students learn these three principal components of science, use of scientific inquiry is needed as instructional strategy which provides the basic scientific skills such as observation, measurement, inferring, experimenting conclusion e.t.c. Inquiry skills help to guide the learner to gain understanding of scientific enterprise.

The inquiry method of science teaching does not only enhance the understanding of nature of science but tends to enhance meaningful learning and achievement in science content. Mari (1994) established a strong relationship between understanding of processes of science and product of science.

The Nature of Science (NOS) addresses the characteristics of scientific knowledge itself and is perhaps easier described than defined. It depicts science as an important way to understand and explain what we experienced in the natural world, and acknowledges the values, beliefs and confidence inherent to the development of scientific knowledge. This description above about the components of scientific literacy is in line with Bianchini, & Colbrun (1998) who views nature of science as contextual values which include both the social and cultural context in which science is done.

The Inquiry strategy helps students to understand nature of science as they will be able to gain understanding of the importance of the creative and logical processes of science as a body of knowledge through science as a method (Khisfe, 2012). He further asserted that inquiry paves way for students to discover answers to questions through

logical procedures rather than listen to answers. This process develops the students' critical thinking abilities and encourages them to become lifelong learners.

Rusell, (2006) opined that inquiry instructional strategy develops science process skills; these process skills like ability to formulate questions, collect and interpret data, reflect to determine principles seeking operations of system, seek for evidence and proofs among students. Exposures to these activities provide knowledge of scientific development and builds students' self-efficacy to explore further for deeper understanding. Usman (2011) also asserted that inquiry instructional approach enhances students' academic achievement in science. Academic achievement is an expression used to present students' scholastic standing and which is a function of various factors such as method of learning, students home background, attitude, interest, self-efficacy, understanding, among others (Popoola, 2010). This shows that any instructional strategy that inculcates these variables could enhance student's performance. As studies like Adamu (2013) reported that activity-based instruction way of learning enhances students' academic achievement and self-efficacy than the lecture method. In the same line, Usman (2000) reported that learning by experimentation or doing enhances students' academic achievement and understanding of the subject content. In view of this, it can be deduced that, inquiry instructional strategy enhances students' academic achievement, self-efficacy and understanding of nature of science. Forehand (2005) reported that scientific inquiry improves students' performance in science subjects at all levels of education. However, Chinn and Malhotra (2002) criticized inquiry instruction because it lacks certain features of authentic scientific challenges such as activity that involves real-world problems and that mimics the work of professionals; the activity involves presentation of findings to audiences beyond the classroom, use of open-ended inquiry, thinking skills and metacognition, students engagement in discourse and social learning in a community

of learners and students direct their own learning in project work. But the aspect of Inquiry they are referring to is not well spelt out. This suggests that there may be aspects of scientific knowledge, in particular knowledge on the problem-solving level, which cannot be learnt well with this instruction but any other method.

Lecture method of instruction is mainly verbal presentation of ideas, concepts and generalization of facts (Adamu, 2013). He opined that learning is experience-dependent, which can be observed in some students with high reasoning ability when exposed to some subjects using lecture method. Using lecture method, the learner has to relate the concept learnt with previous knowledge to make learning meaningful. Thus, these are enough reasons to suggest that lecture method could enhance logical reasoning, academic achievement, learner self-efficacy and understanding of nature of science; hence there is the need to determine which of the instructional strategies is more effective for learners to portray these skills. Based on this view, Danjuma (2005) and Otuka (2006) reported that about 80-90% of the scientific information or principles students received from their teachers come through lecture method. It is commonly used as it aids early coverage of course outline, saves time and does not involve "hands on" "minds on" principle. While Usman (2000) oppose the use of lecture method in teaching science as he view learning by experimentation or doing to be more lasting. These learning by experimentation will aid effective learning of nature of science, since experience will assist the learners' to link past with present, using activity-based instructional strategy will assist the_learners to acquire skills of experimentation, logical reasoning ability, and so on, which are some of the skills acquired if a learner is exposed to a subject using inquiry instructional strategy as it enhance understanding of the nature of science and increase students self-efficacy. In this study lecture method will be use for the control groups so as to assess it effect on understanding of nature of science.

The term “self-efficacy” was proposed by Bandura (1986) and defined as the “Judgment of one’s capacity to accomplish a certain level of performance” It seems to imply a degree of preparedness by virtue of training, experience, or talent (Housego, 1992). According to Bandura’s (1986) theory of social learning, an individual’s self-efficacy refers to that person’s judgments about how well one can organize and perform an action that has unpredictable and stressful components. Bandura (1977) described two critical components of self-efficacy. The first component is “efficacy expectation,” which represents the belief in one’s ability to successfully perform the behavior. The second component of self-efficacy is “response outcome expectancy,” which is the belief that the performance of the behavior will have a desirable outcome. Bandura (1997) focused a number of studies of teacher behavior and found that teachers who have a high sense of self-efficacy have a strong desire to teach, make efforts to motivate students and provide students with guidance. At the same time, teachers with low self-efficacy spend less time on instruction, make little effort to motivate students, and have an authoritarian approach.

Self-efficacy is more than just confidence, as one can be confident about failing a particular Endeavour (Pajares, 2002). Self-efficacy refers to the belief that an individual can organize and successfully execute courses of action (Pajares, 2002). If individuals believe that their actions will produce an outcome they desire, they will be more likely to be preserving in the face of resistance (Pajares, 2002).

Pajares (2002) opined that in inquiry instructional strategy individual believe in such a way that their actions produced an outcome that they desire, and that their high self-efficacy through inquiry reflects how well knowledge and skill was acquired. In the same view Rusell (2006) asserted that learner level of self-efficacy determines successful completion of a given task through inquiry as learners of low self-efficacy tend to perform low academically while learners with high self-efficacy perform high in

academics. Researchers like Debroux (2007) examined the effect of guided questioning on students' performance, self-regulatory behaviour and self-efficacy among biology students who are not majoring and found that guided questioning on nature of science enhanced individual self-efficacy and improve academic achievement of the learners, this was done by posing some problems such as how molecules move through semi permeable membrane and gave them procedures in conducting the experiment without telling them what the outcome will be in other to test their level of understanding of nature of science

Researchers such as Pajares (2002) Rusell (2006) and Debroux (2007) opined that students with high self-efficacy can perform high academically and understand, since it involves confidence one has in performing a given task. Likewise researchers like Kardash (2000); Hunter, & Laursen (2007) reported that the positive impacts of inquiry on students' self-efficacy, ability to think and work like scientists and their understanding of investigation processes, that is the practical understanding of the nature of scientific knowledge and how science is conducted is gender friendly.

Gender is also considered an essential component related to science performance research (Baker, 2000; Kahle & Meece, 1994; Krockover & Shepardson, 1995). This is very much in line with the investigation carried out by Lynch (2000), Rodriguez (1998), and Stevens (1993). Scantlebury (1994) claimed that most cultures led females and males into different experiences; hence, they start school with different knowledge, expectations and self-confidence in learning.

Gender differences with respect to reasoning and respond to instructional mode is often significant and require attention (Usman, 2011). For example Usman (2011) clearly showed that such male and female differences in learning frequently occur. As Usman pointed out, male-female differences themselves possess little explanatory value. It is very important, however, to understand how and why these differences emerge. Thus

looking at male-female differences from the perspective of the focus of this study could yield important information regarding how and why such differences arise. Many studies carried out by some scholars such as (Spencer, Hyde, 2005; Johnson and Markham, 2004 and Akerson, Cary & Donnelly 2007) to examine the relationships between gender differences and instructional strategies in science affirmed that the nature of this relationship is far from being resolved.

Arsaythamby et al (2013) share the same view with Usman and Adamu. Other research findings however tend to show that irrespective of the instructional strategy employed in science teaching, girls do not achieve nor develop cognitively and self-confidence as much as boys in science (Erickson, 2004). In this study therefore the performance and self-efficacy of male and female students expose to structured inquiry instruction and lecture instruction will be determined and also to investigate if structured inquiry instruction is gender friendly or not.

Therefore, it is important to understand the relationship between nature of science and structured inquiry to better support the development of scientific literacy. As such, this study tends to investigate the impact of structured inquiry on NCE biology students' academic performance, self-efficacy and understanding of nature of science (NOS) which have not been adequately explored.

1.1.1 Theoretical Framework

The theoretical basis for this research work is the Schwab (1960) Inquiry-based learning model and Bandura (1991) which advocate on the active nature of learning. Joseph Schwab was one of the founders of the inquiry-based learning model that relies upon the idea that individuals are able to learn by investigating scenarios and problems through social experiences. Rather than having to memorize information from printed materials, instructors encouraged their students to conduct investigations that would

satisfy curiosity, help them broaden their knowledge base and develop their skills and mental frames. Schwab (1960) emphasized on the need for inquiry-based learning as it is geared towards increasing level of understanding of the nature of science in science teaching and learning.

Bandura (1991) stress that self-efficacy can enhance academic performance as it was developed by four main sources of influence. The most effective way of creating a strong sense of efficacy is through mastery experiences. Successes build a robust belief in one's personal efficacy. Failures undermine it, especially if failure occurs before a sense of efficacy is firmly established. Bandura (`1991) conducted much researches on the four major psychological processes through which self-efficacy affect human functioning and highlighted the various components affected which is as result of the nature of learning instructional strategy applied, such components are cognitive processes, motivational processes, affective processes and selective processes. He further stresed that inquiry learning instructional strategy produced positive responds to all the four components listed. These two theories are fundamental basis of this research work as it entail planned activities that has to be carried out by students. Therefore, this study is to investigate the impact of inquiry instructional strategy on NCE biology students' self-efficacy and understanding of the nature of science.

1.2 Statement of the Problem

Teachers who teach science may not hold clear ideas about the Nature of Science. (Abd-El-Khalick & Lederman, 2000; Abell & Smith, 1994; Lederman, 1992). The NOS is described as the epistemology of science, science as a way of knowing, or the values and beliefs fundamental to the development of scientific knowledge (Lederman, 1992). Teachers may have no clear meaning of the values held by scientists or the assumptions scientists make while developing scientific knowledge (Lederman, 1992). This lack of

understanding becomes problematic as teachers are being asked by the current science education reforms (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996) to teach science so that it is reflective of contemporary science research.

Despite the extensive amount of research conducted in the field and prominence of this important component of scientific literacy in the reform documents, the development of informed NOS views has been difficult goal to achieve, with many studies reporting difficulties in changing learners' NOS views (Duschl, 1990; Lederman, 1992). Importantly, research has highlighted the effectiveness of explicit NOS instructional approaches in improving learners' views of NOS (e.g., Abd-El- Khalick & Lederman, 2000; Hanuscin, Akerson, & Phillipson-Mower, 2006; Schwartz, Lederman, & Crawford, 2004). This approach is contrasted with implicit instructional approaches to teaching NOS which are underpinned by the view that an understanding of NOS will result from engaging students in inquiry-based activities, without the addition of deliberately-focused (explicit) NOS instruction.

James (2000), Usman (2000) and Duwan (2011) have suggested the use of inquiry teaching method which is an activity-based method in remediating problems of low achievement science subjects like Biology, Chemistry and Physics at both secondary and tertiary schools in Nigeria. The use of inquiry-based instruction in developing learner content knowledge and self-efficacy has received a lot of attentions from researchers; this is because the inquiry learning strategy can inculcate the content knowledge as it increases learner's performance and self-efficacy (Heather, 2013). In order for NCE students to gain understanding of the nature of science and high self-efficacy to teach the science content, they need to have opportunities to learn through experiencing the same

processes that they will use for instruction in the future and reflecting on the personal experiences gained through such (Heather, 2013).

Bandura (1997) pointed out that self-efficacy is the ability to perform activities within a particular domain and has a strong influence on learner's performance. Learners are expected to exhibit certain level of confidence in their ability to perform or learn task before they become successful.

Therefore, in this research work the researcher choose to use cell biology to teach nature of science using structured inquiry instruction to compare it with the traditional method which encourages memorization of facts.

1.3 Objectives of the Study

The study has the following objectives to:

1. determine the impact of inquiry instructional strategy on NCE I biology students' understanding of the nature of science.
2. determine if use of inquiry will increase NCE I biology students' self-efficacy.
3. Find out the impact of inquiry instructional strategy on male and female NCE I biology students' understanding of nature of science and self-efficacy.
4. determine the relationship in self-efficacy and understanding of nature of science of NCE biology students using inquiry instructional strategy.

1.4 Research Questions

The following research questions will be investigated:

1. What is the difference in understanding of nature of science by NCE I Biology students exposed to inquiry instructional strategy and those taught using lecture method?

2. What is the difference in self-efficacy of NCE I Biology students exposed to inquiry instructional strategy and those exposed to lecture method?

3. What is the difference in self-efficacy and understanding of nature of science by male and female students after exposure to inquiry instructional strategy?

4. What is the relationship of self-efficacy and understanding of nature of science among NCE biology students using inquiry instructional strategy?

1.5 Null Hypotheses

The following null hypotheses were formulated to guide the study.

$H_{O1:}$ There is no significant difference in mean scores in NOSUT by NCE I Biology students taught cell biology using inquiry method and those taught using lecture method.

H_{O2}: There is no significant difference in the mean scores in the NOSSEQ of NCE I biology students' taught cell biology concepts using inquiry instructional strategy and those taught using lecture method.

H_{O3}: There is no significant difference in self-efficacy and understanding of nature of science by male and female NCE I biology students taught cell biology using inquiry instructional strategy.

H_{O4}: There is no significant relationship between NCE Biology students understanding of nature of science and their self-efficacy after exposure to inquiry instructional strategy.

1.6 Significance of the Study

The findings of this research will hopefully be significant in number of ways;

1. **Students**: The subjects in this study will benefit from exposure to inquiry-based learning as it supposed to enhance their performance, self-efficacy and provides deep understanding of the nature of science in Biology Concepts.

2. If used, it could influence participating teachers in training to adopt this as medium of instructions after graduation. The motivation, deeper understanding of concepts and skills they obtained will be expected to inspire them to adopt the method to teach after graduation.
3. It will provide the avenue for developing students thinking processes.
4. NCE students will benefit from the finding, the various ways in which they could improve their academic performance, self-efficacy, and understanding of the nature of science.
5. **Teachers:** The findings of the study would be useful to Science Teachers Association of Nigeria (STAN) in preparing workshops and conferences for science teachers' effective instructional method that could promote academic achievement, self-efficacy and understanding of the nature of science among learners.
6. **Professional bodies:** The study could be useful to National Union of Teachers (NUT) and National Teachers' Registration Council of Nigeria (NTRCN) in preparing an in-house training on teaching strategies for their members. The in-house training could be conferences and seminars where experts on teaching strategies can be invited to present paper for effective lesson delivery.
7. **Textbook publishers:** Science Textbook publishers could find this work useful as it could assist them in selecting materials and practical-questions based exercises to be incorporated in the text that could promote academic achievement, self-efficacy and understanding of the nature of science.
8. **Curriculum planners:** The findings of this study will be beneficial to curriculum planners and administers by inculcating the method into the school curriculum and ensure that it is been used by the teachers and students respectively.

1.7 Scope of the Study

The study will cover two colleges of education out of the three, NCE I biology students in this Colleges of Education i.e. Kwara state college of Education (Technical) Lafiagi, and Kwara State College of Education IIorin while Kwara State College of Education Oro was used for the pilot testing. The schools are co-educational.

There are two thousand two hundred and seven students offering biology as a course at the NCE I level in the three Colleges presently where Forty five students were randomly selected from each of the two colleges sampled out giving the sum of Ninety students out of the population of one thousand four hundred and sixty seven students as the sampled population. With the age range between 19-22 years. The course selected is BIO112 which is titled as Cell Biology in the National Commission for Colleges of Education (NCCE) curriculum. The reason for the selection of the course and level was that the course has "hands on" activities that students of that level can execute without much difficulty. The component of this course includes cell and it physical processes. These topics mentioned will be taught using structured inquiry and lecture method instructional strategy.

1.8 Basic Assumptions

This study has the following basic assumptions:

1. The colleges selected for the study are real representation of the three Colleges of Education in Kwara State.
2. Teachers do not put into consideration the ability levels of the students in teaching Biology to NCE 1 students
3. The learning facilities of the selected Colleges are the same as the three Colleges are owned by the Kwara state government'

4. The students of the Colleges selected were enrolled into the Colleges using the same format of admitting students.
5. The selected topics in Cell Biology are appropriate to the level of the subjects used for study as it was designed by the NCCE.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This study is aimed at determining the impact of structured inquiry-based instruction on NCE biology students' self-efficacy and understanding of nature of science. This chapter critically reviews literature related to the study under the following subheadings:

2.2 Nature of Science

2.3 Learning of Cell Biology at NCE Level

2.4 Nature of Science and Inquiry

2.5 Concept of Inquiry Approach in Learning

2.5.1 Relationship of Inquiry Instruction and Nature of Science

2.5.2 Relationship of Inquiry Instruction and Understanding of the Nature of Science

2.5.3 Relationship of Inquiry and Understanding in Education

2.6 Importance of Inquiry Skills in Science Education

2.7 Concept of Inquiry Learning Models

2.8 Traditional Method of Learning (Lecture Method)

2.9 Concept of Self-Efficacy in Education

2.9.1 Self-Efficacy and Science Learning

2.10 Measuring Understanding of the Nature of Science among Different Groups

2.10.1 Science Curricula and the Development of Understanding of the Nature of Science.

2.10.2 Instruments for Measuring Understanding of the Nature of Science.

2.11 Overview of Similar Studies

2.12 Implications of the Literature Reviewed for the Present Study

2.2 Nature of Science and Inquiry

In a comprehensive review of the literature, Abd-El-Khalick and Lederman (2000) concluded that the attempts undertaken to improve science teacher's nature of science (NOS) views were generally not successful in helping teachers develop understandings that would enable them to effectively teach about NOS. nonetheless, of the approaches utilized by researchers, an explicit reflective approach (Akerson, Abd-El-Khalick & Lederman, 2000) was relatively more effective in improving elementary teachers' views than an implicit approach that utilized hands-on or inquiry-oriented science activities lacking explicit references to NOS (Bianchini & Colburn, 2000).

Abd-El-Khalick & Lederman, (2000) emphasized that tertiary science students who are under training of how to become a good teacher often complained that NOS instruction and activities they experienced in science methods courses did not help them address NOS instructionally during teaching practice. They attributed this lack of utility to the fact that instruction and those activities were embedded in science teaching methods rather than science content. It seemed that the different contexts within which our NCE students learned about NOS (science methods courses) and in which they were expected to apply their knowledge (science content courses) compromised their ability to translate their NOS conceptions into actual classroom practices. A possible way to ameliorate this constraining factor and enhance such translation would be to develop NCE students' NOS understandings in the context of science content courses.The researcher therefore came up with an outline from Maskiewicz & Winters (2012) based on the explanation of what nature of science is and how inquiry serve as basis of instruction in achieving it.19

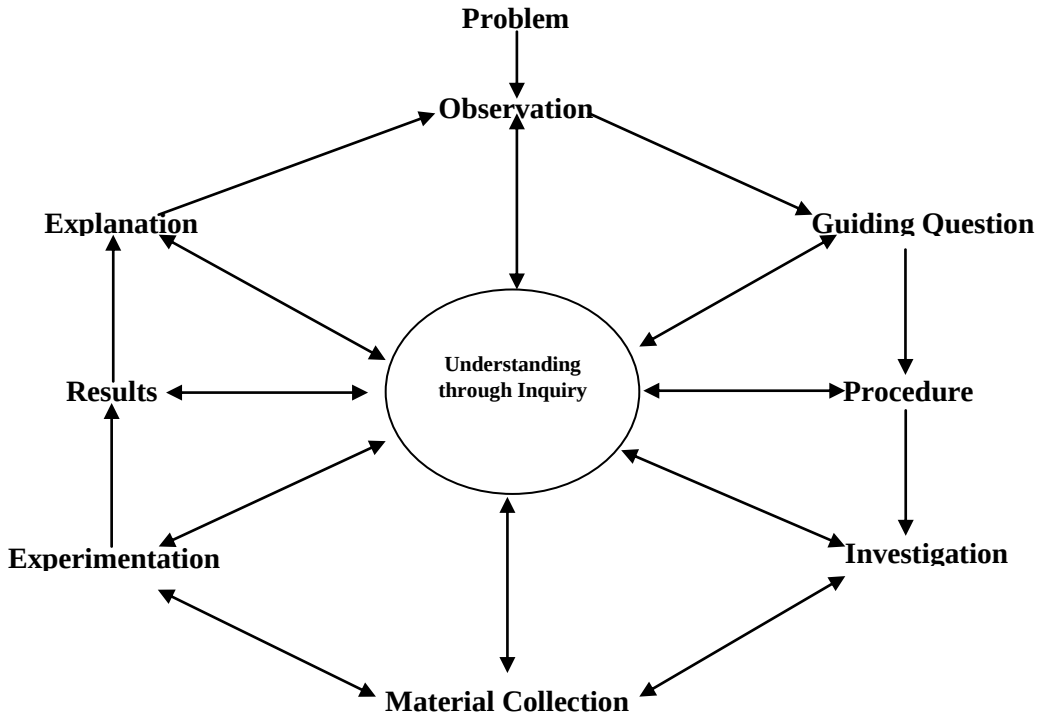


Figure 2.1: An Outline of knowledge structure of NOS and structured inquiry

The above outline is a two way flow chart, the first flow is called Cyclical Pattern Flow of Nature of Science (CPFNS) through inquiry in which a problem is seen initiated by the teacher to the learners and the learners made a critical observation of the problem so that they can raise guiding questions about the problem, after which procedures for solving the problem are generated by the learner from the guiding question(s). learner then try to investigate the procedure(s) in order to validate its reliability and efficacy (CPFNS) after which materials to be use for experimenting are collected by the learner.

Randy, B; Maeng, J.L; & Erin, E.P, (2010) provided a clear picture of the appropriate aspects of the nature of science which should be learnt at all levels of education in any society as

i. Scientific knowledge is empirically based

ii. Scientific knowledge is both reliable and tentative

iii. Scientific knowledge is the product of creative thinking

iv. Scientific knowledge laws and theories are different kinds of knowledge.

v. Scientists use many methods to develop knowledge and

vi. Scientific knowledge is subject to a degree.

After the experimentation, the learner obtain his result and explain the outcome of the experiment which now tell the learner if the result obtained is the answer to the problem or not. For the learner to be able to follow through all the steps involved in the cyclic pattern of nature of science he has to understand how the pattern works and the structured inquiry instruction then determines the level of understanding of the learner in respect to each components of the model.

The second flow of the outline is called Intra-Pattern Flow Nature of Science (IPFNS) through inquiry instruction, where each component of the cyclic outline can be executed successfully if understood and likewise the result of each component which is a proceeding of next level, depends on the level of its operational understanding.

The effects of science on human life and thought have become so great and are potentially so much greater than those who have no understanding of them, and of the science which produce them, cannot be considered properly educated or truly cultured and therefore are unable to participate fully in the life of their home.

How to gain advancement in science and technology has become a vital goal of every sovereign nation as well as a cause for more competition among the leading nations. For example the traumatic shock of sputnik 1 lunched in 1957 by Russian left marks still visible today. Determined never to be so humiliated again, the United States of America reorganized its science education, science funding and scientific research (Abah, 1979). Such a measure has today led the United States to the forefront in science and technology, for she remains the first nation to land man on the moon and bring him safely back to earth. This was made possible because of their ability to organize and give proper guidance to their science education program particularly emphasizing the understanding of nature of science.

Development of understanding of nature of science has been described by Chen, (2006) as of the most commonly stated objectives for science education. Tsai and Liu's (2005) also referred to this aim as "probably the most important purpose for science teaching and learning" concern for this aim has been evidenced in many countries as exemplified by the following instances, given by Millar, & Duschl, (2003). The American Association for the Advancement of Science has established a commission of science education with the stated purpose "to foster, in every way possible, scientific literacy among the American people. In England, the Association of Science Education in it policy statement on science and education has stress the important of developing an understanding of the nature of science among school pupils. The International Conference on the Education of Professional Physicists included among its recommendation that the development of this objective should be given most serious consideration in the modernization of physics education. From various literatures, it is full with the writing of leading scientists, science philosophers and science educators who continue to stress that an understanding of the nature of science is important for several reasons, among which are the following:

1. It would enable citizens to be more capable of making the right decision in terms of policies related to science. On this general need for scientific literacy, Schwarz and Lederman (2002) once said; it is important that all of us, whether we be businessman, teachers, students, lawyers or housewives understand and appreciate the role of science in modern life, such broad understanding will help us achieve spiritual harmony with our environment, and exercise our duties as citizens in making political decision which more and more are influenced by latest scientific discoveries.

2. An understanding of the true nature of science would create in citizens an awareness of the fact that certain library education value such as curiosity, honesty, open mindedness, objectivity, pursuit of truth, respect for logic, among others, are characteristic of the spirit of science.

3. Knowledge of the nature of science is important to scientists in that it serves as a foundation for originality in scientific ideas by providing an awareness of the professional techniques and ethics for practicing real science. According to Chen (2006) that foundation is not any particular body of factual knowledge but a way of thinking and acting which together form the scientific method. Science in fact, is what scientists do. Study of scientific method is the study of how they do it and is properly a branch of psychology particularly important to all practicing scientists and to anyone who is interested in scientists and science.

4. A sound understanding of the nature of science is highly desirable on the part of science teachers because in other to lead their students in to realizing this objective, teachers themselves would need to be well versed in these same tenets. Besides, teaching students so that they can attain better understanding of the nature of science cannot successfully be done through lecture method, for the spirit of certainty upon which lecture method rests is contradictory to the spirit of science (Educational Policies Commission, 1966). Therefore, this objective calls for a careful planning and integration of the process of science in to the teaching activities and instructional programs. This places further values on knowledge of the nature of science on the part of science teachers.

5. Knowledge of understanding of nature of science is also important to scientist in that it increase the level of self efficiency in individual. This is because the

acquisition of the knowledge was done by the individual during the process of conducting an experiment.

However, from the above listed importance of understanding of nature of science Eshach and Fried (2005) pointed out that to teach science well it is necessary to know what science is, what its purpose and meanings are. They further stressed that since an understanding of the nature of science is a major goal of science teaching, provision for its realization should not be limited to only the junior and senior secondary schools, but should be pursued at all arms of our educational system. Mari (2001) observed that for students to understand the nature of scientific enterprise, suitable instructional strategies must be adopted. This calls for investigation to determine the suitability of every instructional method in its ability to promote understanding of nature of science. This study determines if inquiry instructional strategy enhances the understanding of nature of science when to teach NCE students Biological concepts or not.

An informed understanding of nature of science (NOS) is a crucial component of scientific literacy (Bybee, 1997; DeBoer, 1991). To produce a scientifically literate population NOS has been deemed an important part of the science curriculum (Rudolph, 2000). Teachers hold many misconceptions of NOS, and therefore have difficulty teaching an appropriate view to students (Abell & Smith, 1994; Akerson, Abd-El-Khalick,&Lederman, 2000; Lederman, 1992).We have found that most elementary teachers have not heard the term ‘‘nature of science,’’ and when they see it in their state frameworks they misinterpret the term as meaning something to do with nature, not as the essence of science itself. These teachers cannot teach about NOS without first improving their own views (Akerson & Abd-El-Khalick, 2003).

Nature of science (NOS) refers to the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge

(Lederman, 1992). Rudolph (2000) urges an emphasis on NOS in the science curriculum despite the debate of what exactly constitutes NOS. In their nature of science position statement, the National Science Teachers Association (2000) recommends that science, along with its methods, explanations, and generalizations, must be the sole focus of instruction in science classes. Their position on what teachers and students should know includes that: (a) scientific knowledge is both reliable (one can have confidence in scientific knowledge) and tentative (subject to change in light of new evidence or reconceptualization of prior evidence); (b) no single scientific method exists, but there are shared characteristics of scientific approaches to science, such as scientific explanations being supported by empirical evidence, and are testable against the natural world; (c) creativity plays a role in the development of scientific knowledge; (d) there is a relationship between theories and laws; (e) there is a relationship between observations and inferences; (f) although science strives for objectivity, there is always an element of subjectivity in the development of scientific knowledge; and (g) social and cultural context also play a role in the development of scientific knowledge. Because these are the ideas that teachers need to be able to teach to their own students, it is these NOS elements that is the focus of the present study.

In general, the nature of science refers to key principles and ideas which provide a description of science as a way of knowing, as well as characteristics of science knowledge (Abd-El-Khalick & Lederman, 2000). Many of these intrinsic ideas are lost in the everyday aspects of a science classroom, resulting in students learning skewed notions about how science is conducted (Abd-El-Khalick & Lederman, 2000). However, research studies have consistently shown that students' views are not consistent with contemporary conceptions of the scientific endeavor

(Akerson, Abd- El-Khalick & Lederman, 2000), it is unlikely that students who ascribe to naïve conceptions of nature of science would be able to help their students develop informed nature of science view.

Various approaches have been undertaken to enhance students' views of several important aspects of nature of science with differing levels of success (Abd-El-Khalick & Lederman 2000). Although there is question whether substantial changes in students' nature of science conceptions could be achieved in a single science methods course, there is some support that limited success could be had in such a setting (Shapiro, 1996). Recent studies (Abd-El-khalick, 2001; Akerson *et al.*, 2000) indicated that using inquiry instructional strategy to help tertiary students achieve informed nature of science views might be even more effective, especially if such an approach were undertaken from within a conceptual change framework (Abd-El-Khalick & Akerson , 2004).

Research has shown that a relationship is more complex when viewing the relationship between students' nature of science understanding and their instructional practices Abd-El-& khalick *et al.* (1998) Bell, Crowford & Lederman. (2003). Abd-El-Khalick & Lederman, (2000) also opined that students cannot learn what they do not understand. A number of natures of science in (mostly) the North America and Australian context (Lederman, 1992). These studies found that a majority of high school students often lacked an understanding of various important aspects of nature of science, including the role of creativity in science (Abd-El-Khalick, 2006, Bell Blair, Crowford, & Lederman, 2003). The nature and relationship between the various types of scientific constructs (e.g hypotheses, theories, and laws). (Abd-El-Khalick, 2006; Bell *et al.*; 2003), tentativeness of scientific knowledge (Bell *et al.*; 2003; Lederman & O' Malley, 2012). The nature and functions of scientific models (Mackay, 2001); and the nature of scientific reasoning (Tamir & Zohar, 1991).

Outside the North American context, Kang, Scharmann and Noh (2005) assessed the understandings of 1,702 grade 6,8,10 Korean students of the purpose of science; nature of models; and definition, origin and tentativeness of scientific theories through inquiry instructional technique. The researchers found that a majority of their participants ascribed to absolutist/empiricist views of nature of science. No clear differences were evident between the responses of students from the three participant grade levels. The authors also reported some differences between the nature of science views participants Korean students and their counterparts in Western countries.

The study is there aim to investigate the impact of structured inquiry instructional strategy on self-efficacy, and academic achievement of NCE students in skeletal system.

2.3 Learning of Cell Biology at NCE Level

Biology deals with the study of science of life. Although Biology as a single science subject divided into many branches e.g. zoology i.e. study of animal, botany i.e. study of plant and general Biology such as microbiology, ecology, genetics, anatomy and physiology and cell biology which deal with the study of cell and the physical processes of the cell such as diffusion, osmosis and plasmolysis. (Micheal, 2002).

Cell biology as specified in N.C.E. I syllabus (BIO 112) covers such topics as concept of cell, physical processes of cell such as diffusion, osmosis, plasmolysis at NCE level. These cell and its physical processes pose some difficulties for students to understand especially with the use of inappropriate methods of instructions often employed by their teachers (Adamu, 2013). Diffusion and osmosis are the two major concepts in physical processes of cell which are to be taught experimentally through scientific method as they involve the movement of molecules from one level to the other. Here the aspect of diffusion and osmosis to be discuss will include: experiment to show

diffusion of water molecules through a semi permeable membrane from a higher concentration to a lower concentration, reaction of cells to a solute concentration.

This study therefore investigates the impact of inquiry instructional strategy on self-efficacy and understanding of the nature of science of N.C.E. biology students in cell biology.

2.4 Nature of Science and Inquiry

All those involved with science teaching and learning should have a common, accurate view of the nature of science. Science is characterized by the systematic gathering of information through various forms of direct and indirect observations and the testing of this information by methods including, but not limited to, experimentation. The principal product of science is knowledge in the form of naturalistic concepts and the laws and theories related to those concepts.

According to Duschl, 2012; Krajcik & Merritt, 2012; Reiser, Berland, & Kenyon, 2012. The nature of science is included in the *Next Generation Science Standards*. Here we present the NOS Matrix. The basic understandings about the nature of science are:

i. Scientific Investigations Use a Variety of Methods

ii. Scientific Knowledge is Based on Empirical Evidence

iii. Scientific Knowledge is Open to Revision in Light of New Evidence

iv. Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

v. Science is a Way of Knowing

vi. Scientific Knowledge Assumes an Order and Consistency in Natural Systems

vii. Science is a Human Endeavor

viii. Science Addresses Questions About the Natural and Material World

The first four of these understandings are closely associated with practices and the second four with crosscutting concepts. The NOS Matrix presents specific content for K-2, 3-5, middle school and high school. Appropriate learning outcomes for the nature of science are expressed in the performance expectations.

Science is a methodical approach to studying the natural world. Science asks basic questions such as; how was the world like in the past, what is it like now, and what will it be like in the future? These questions are answered using skills of nature of science such as observation, hypothesizing, testing, and collecting data and interpretation through logic (Abd-El-Khalick *et al.*, 2000). Advocacy for students' understanding of science and its nature can be traced back to the early years of this century. For example, Lederman (1992) reported that the central Association of science and math teachers in 1907 strongly emphasized the specific method and processes of science teaching. William & Harven. (2011) cites Dewey's 1916 in argument that understanding scientific method is more important than the acquisition of scientific knowledge. They further stressed that there are two aims of science teaching one is knowledge, and the other is enterprise. From the science courses, students should acquire a useful command of science concepts and principles, as science is more than a collection of isolated and asserted facts. A student should learn something about the character of scientific knowledge, how it has been developed and how it is used (William et al, 2011).

In addition to learning the processes of doing science, researchers and program developers have hoped that students would learn about the scientific enterprise through participation in authentic science experiences (Krajcik, Blumenfeld, Marx, Bass, Fredricks & Soloway, 1998; Moss, Abrams, & Kull, 1998. In other words, students are expected to make gains in their understandings of the nature of science and scientific inquiry. This learning is sometimes seen as a natural outcome of students' participation in

scientific inquiry. For example, Moss et al. (2001) expected high school students to learn about the nature of science through collaboration with scientists on research projects. Speaking about their own expectations for the project, Moss et al (2001) explained:

"The inclination to think that the nature of science can be taught implicitly was clearly evident in this study. It was assumed that if students were actively engaged in doing science in this project-based class, they would as a by-product of those experiences develop a deep understanding of the nature of science. (Moss et al., 2001, p. 788)"

Structured inquiry learning strategy has been characterized in a variety of ways over the years (Rust, 2011) and promoted from a variety of perspectives. Some have emphasized the active nature of student involvement, associating inquiry with "hands-on" learning and experiential activity based learning instruction. Others have liked inquiry with a discovery approach or with development of process skills associated with "the scientific method". From a pedagogical perspective, inquiry learning is often contrasted with more traditional expository methods and referred to as active learning, so strongly advocated for among science educators (Mari ,1994).

In classrooms where students are encouraged to make meaning, they are generally involved in developing and reconstructuring (their) knowledge schemes through experiences with phenomena, through exploratory talk. Since not all science instruction allows students to have understanding of nature of science being a goal of science teaching, science method must always be tested to determine their capability to inculcate understanding of science. From the above views, this study is therefore aimed at investigating the impact of inquiry instructional strategy on NCE Biology students' self-efficacy and understanding of the nature of science in vertebrate anatomy and physiology.

2.5 Concept of Structured Inquiry Approach in Learning

Inquiry means that students are handling science; they are manipulating it, working it into new shapes and formats, integrating it into every corner of their world, and playing with it in unknown ways. Inquiry implies that students are in control of an important part of their own learning where they can manipulate ideas to increase understanding. As students learn to think through the designs and developments of their own inquiry, they also develop a sense of self-responsibility that transcends all subject areas (Colburn, 2000).

Many science textbooks portray science as a collection of facts or a body of knowledge for students to learn. Unfortunately, the impression this may leave with students is that studying science is nothing more than memorizing facts and mastering theories. On the contrary, there is much room in science for intuitive, hypothetical, playful, and imaginative forms of learning. In other words, there is room for inquiry.

"Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world."

Inquiry approach in learning is one of the instructional strategies that are activity based. Brunner (1961) postulated this method in science teaching and learning. Research findings of science educators like Jegede and Taylor (1998), Okebukola (2002), Tsui and Treagust (2002) revealed that those learning instructions that are activity- based such as structured inquiry which involved the learner taking active role in the learning process, results in better learning and increase in self- efficacy and understanding of nature of science on the part of the students structured inquiry is a learning method that involves

metal skills for learning by students' such as observing, measuring, classifying, formulating, hypothesis, experimenting, data collecting, data analysis, making conclusion, James (2000) and Usman (2000).

While according to Colburn (2011) structured inquiry is described as, students are given a problem to solve, a method for solving the problem and necessary materials but not the expected outcomes.

According to Colburn (2011) structured inquiry is one of the three types of inquiry namely;

1. Structure inquiry
2. Guided inquiry
3. Open inquiry

Guided inquiry is a strategy of learning through which students are given a problem to solve, but they have to figure out a method for solving the problem given (Colburn, 2011). The teacher provides the problem for investigation as well as the necessary materials. Students are expected to devise their own procedure to solve the problem. Guided inquiry is grounded to describe students' process of learning (Kuhlthau, 2007). Kuhlthau identified six stages of guided inquiry to be Initiation of problem, Formulation of hypotheses, Procedure for exploiting the problem, Collection of materials, Experimenting and Presentation of the result. Studies on research learning method shows that this approach has a positive influence in students' academic success (Blonder, Naamam & Hofstein, 2008. Ertepinar and Geban, 1996) their self-efficacy Bandura (1991), but it is time consuming (Furtak, 2006).

Open inquiry is a learning strategy where the students formulate the problem they will investigate, derived the method of solving it (Colburn, 2011). Open Inquiry has been defined as student-driven. Similar to Guided Inquiry, students formulate their own

problem to solve as well as the procedure. Open Inquiry is analogous to doing science. Science fair projects are often examples of Open Inquiry.

Open inquiry is also referred to as unguided inquiry which requires a higher order thinking (Orlich, Harder, Callahan & Gibson., 1998). Unguided inquiry is liable to high percentage of errors, time consuming and waste of resources (Furtak, 2006).

In structured inquiry learning strategy, teachers and learners play a crucial role in asking questions, developing answers and structuring of materials to develop their individual responsibility, cognitive methods, report making, problem solving, and understanding skills of knowledge construction. (Magnusson, & Palinscar, 1995).

The teacher establishes parameters and procedures for inquiry. Students are provided with a hands-on problem to investigate as well as the procedures and materials necessary to complete the investigation. Students discover relationships between variables or generalize from data collected, which in essence leads to the discovery of expected outcomes. The value in using structured inquiry is it allows the instructor to teach students the basics of investigating as well as techniques of using various equipment and procedures that can be used in later more complicated investigations. In other words, structured inquiries provide students with common learning experiences that can be used in guided or open inquiry.

According to National Research Council (NRC, 2000), inquiry approach can best facilitate focusing on learning the development of certain scientific concepts, but while the students in the teachers guidance focus their attention onto the content, they have less suitable means for discovering scientific thinking processes and gaining experience (Kai, & Krajak, 2006). Structured inquiry learning method being one of the activity- based methods of science learning is investigated for its effectiveness in learning of biology in relation to students' academic performance and self-efficacy at the NCE level. This is in

line with Ojo & Obembe (2006); Shittu (2012) that each method of learning science subject should be critically analyzed to see its effectiveness in learning processes specifically in biology. This study is aimed to investigate the impact of structured inquiry instructional strategy on NCE Biology students' self-efficacy and academic performance of nature of science using skeletal system concepts.

2.5.1 Relationship between Inquiry Instruction and Nature of Science

Science education reform efforts emphasize teaching science for all Americans, and identify scientific literacy as a principal goal of science education (Donna, *et al.* 2010). However, developing scientific literacy requires a broader view of science that includes three principal components; the knowledge of science, the methods of science and the nature of science (Donna, *et al.* 2010). Scientific knowledge includes all of the scientific facts, definitions, laws, theories, and concepts we commonly associate with science instruction. The methods of science refer to the varied procedures that scientists use to generate scientific knowledge while the nature of science depicts science as an important way to understand and explain what we experience in the natural world, and acknowledges the values and believes inherent to the development of scientific knowledge (Donna, *et al.* 2010).

Inquiry based learning is primarily a pedagogical method developed during the discovery learning movement of the 1960s as response to traditional forms of instruction (Infeanyi, 2013). The relationship between inquiry and nature of science (Ifeanyi, 2013) stressed that inquiry instructional strategy encourage learners understanding of nature of science, improve their academic performance as well as their self-efficacy. Stephen, & Norman. (2014) stated that an individual who is engaged in activity based task by inquiry instruction, work harder and persist longer and understand how the scientific knowledge is been constructed which as a result boost the individual performance and self efficacy.

Ali (2014) asserted that inquiry- based science learning is the driving key to the construction of science knowledge (nature of scientific) as children become engaged in many activities and thinking processes that scientists use to produce new knowledge. Based on the above the present study will hopefully benefit NCE students, since they are trained to be teachers and are expected to exhibit attitudes of scientists in dealing with their students.

2.5.2 Relationship between Inquiry Instruction and Understanding of the Nature of Science

According to Alouf and Bently (2003) Amaral, Garrison & Klentschy. (2002) Jorgenson and Vanosdall (2002), and Van Secker (2002), there are some studies that found a positive relationship in inquiry- based instruction and understanding of nature of science. However there are also studies that showed no significant relationship between inquiry- based instruction and understanding of the nature of science.(Booth, 2001).

Inquiry-based instruction has a positive impact on student learning that is reflected in their understanding of the nature of science and their ability to solve problems (Geir *et al.*; 2008; Hmelo-silver Ducan, and Chinn, 2007). Inquiry helps students to comprehend scientific knowledge and also the way in which students are expected to learn during the process of constructing knowledge (Abd-El-Khalick *et al.*, 2004). Researchers like Aknipar, Yildiz & Ergin. (2009); Tan (2007), and Turhan (2003) shows that learning instructions like problem-solving, demonstration and inquiry are time wasting and consumption of resource and invariably affect students academic performance as they find the activities difficult to manipulate. This study is designed to investigate the impact of structured inquiry instructional strategy, self-efficacy and academic performance of NCE students to show how the result will be.

2.6 Importance of Inquiry Skills in Science Education

Feldman, & Minstrell (2002). Said structured inquiry strategy is one of the most important dimensions of thinking and learning. Nickerson (1994) pointed out several reasons why there is need to engage in effective and function able structured inquiry in science which is critical to the development of individuals and their communities in order of increasing specificity:

1. At the core of the survival of individuals and communities interacting and increasingly complex external environment.
2. Essential to developing and sustaining a democratic society, and;
3. An increasingly sought after high level cognitive ability in the knowledge workplace of today.

Structured inquiry strategy skill is an important intellectual activity for human being's; it is also a very important spring head of human kind's knowledge in science education (May, Hammer, & Roy. 2006). While Hammer, & Van Zee. (2006) opined that inquiry learning strategy in schools is one of the ways the goal of science education, which is to train and produce self constructive scientists who will be enterprising and self reliant, can be fruitfully achieved. Learning by lecture method would not be enough to cater for this goal, science education students need to be acquainted with the structured inquiry skills. Psychologists treat it as a complicated but highly structural progress of mental activities in human beings. It is in this vein, that Hammer, *et al.* (2008) affirmed that the development of structured inquiry skills is a main target in developing countries. It is also the core ability in science education. Usman (2011) considered structured inquiry as a high level deliberation ability that should have the following skills observing, comparing, inferring, hypothesizing, experimenting, data collection and interpretation of data. Bronner (2001) revealed that enhancing the inquiry learning strategy. Capabilities of

students have become a national educational issue in developing countries. The commission on pre-college Education in Mathematics, science and technology (1983) in USA declared that "inquiry ability and scientific and Technological literacy are the thinking tools that allows us to understand the scientific world around us"

In Science and technology education, learning through inquiry instructional strategies has become a central focus of instructional activity (Hammer, *et al.* 2008) it follows, therefore, that students need to be skillful at using inquiry strategies in their classrooms, workshops and laboratories. Several studies highlighted this need. May *et al.* (2006) opined that structured inquiry should be key descriptor for defining science and Technology Education learning competency and a curricular organizer for the study of Science and Technology Education. Louca *et al.*, (2004) reported that an emphasis on structured inquiry learning strategies was key ingredient in assessing the effective implementation of pre – service (NCE) science and technology students. In addition, researches from Hammer *et al.* (2008), and May *et al.* (2006), pointed to the need for NCE graduates of science and technology students to use inquiry learning strategies in their classrooms, workshops and laboratories and to learn inquiry skills.

Despite the acknowledgement of the importance of developing structured inquiry skills, relatively little research has been conducted on this theme in the field of Science and Technology Education especially in self- efficacy and academic performance. It is based on the importance of structured inquiry learning strategy in Science and Technology Education. The research was proposed to investigate the impact of structured inquiry strategy on self- efficacy, and understanding of nature of science in cell biology of NCE students.

2.7 Concept of Inquiry Learning Models

The Inquiry-based Learning Model emerged in the 1960s, during the "discovery learning" movement and relies upon the idea that individuals are able to learn by investigating scenarios and problems, and through social experiences. Rather than having to memorize information from printed materials, instructors encouraged their students to conduct investigations that would satisfy their curiosity, help them broaden their knowledge base and develop their skills and mental frames.

It's important to remember that inquiry-based learning is not a technique or practice per se, but a process that has the potential to increase the intellectual engagement and deep understanding of learners, urging them to:

- Develop their questioning, research and communication skills
- Collaborate outside the classroom
- Solve problems, create solutions, and tackle real-life questions and issues
- Participate in the creation and amelioration of ideas and knowledge

There are so many inquiry-based learning models but for the sake of this research, two of the models reviewed are Heather (2013) and Lederman (2000).

Heather (2013) inquiry model was five steps inquiry pattern as Observation, Collecting data, Understanding the data, Experimenting and discussion of the result (OCUED) and Lederman (2000) six steps inquiry model include Initiation of the Problem, Engagement of students, Experimentation, Explanation, Inference and Communication (IEEEIC).

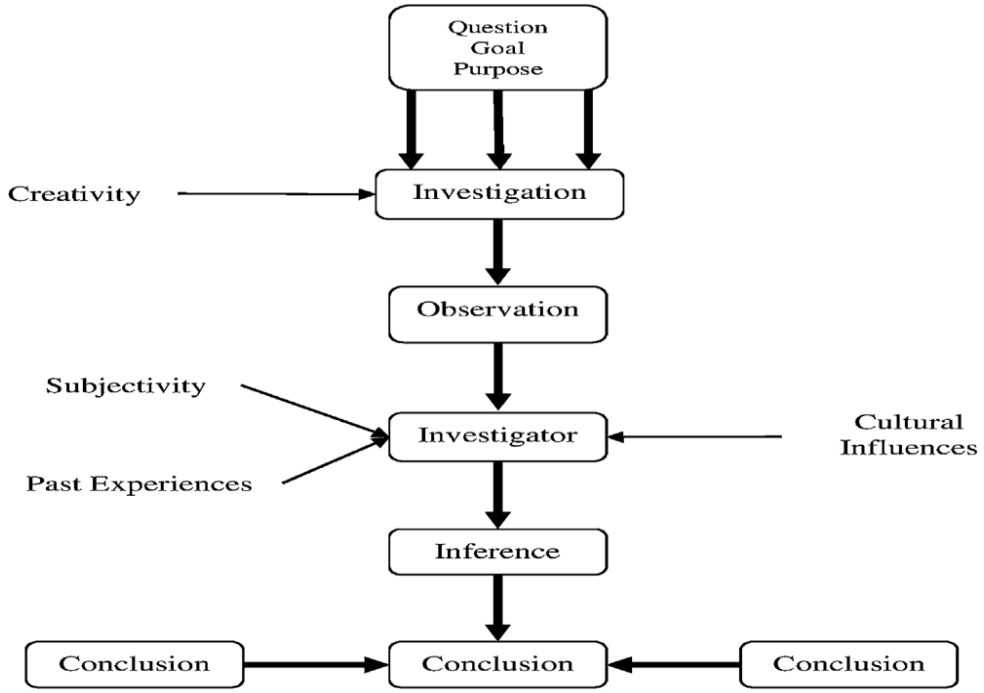
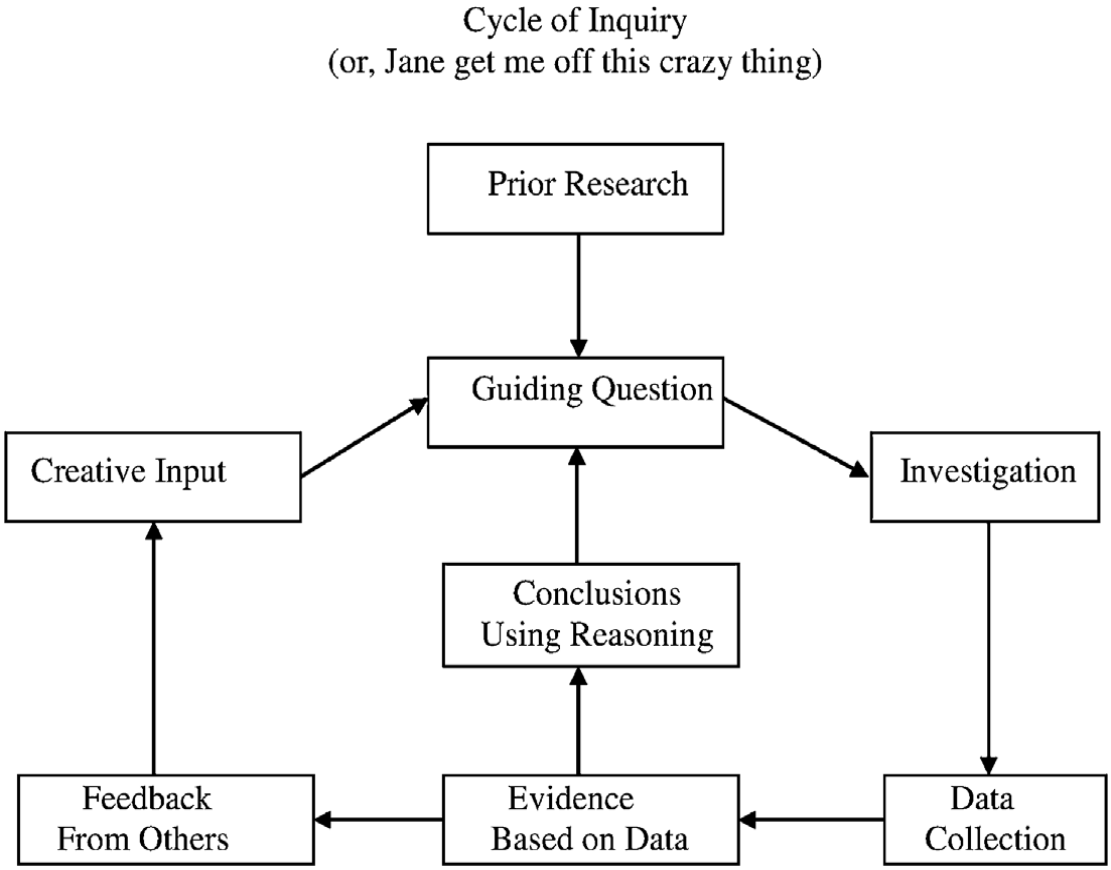


Figure 2.2: Flow chart showing stages of scientific processes

Hatti, (2009), Vince, (2010) work on similar model of inquiry-based teaching and learning and found out how effective it is in enhancing scientific and social science concepts. for example. Vince, in explicating his KS4NS diagram, spoke of how tentativeness was at the very foundation of the cycle of inquiry. Expressed strongly, inquiry, in Vince's view, was anytime you answer a question and end up with new questions," and as a result "you can't ever say for sure, you can't prove anything" (Vince, KS4NS Interview, Q4). In his classroom practice, Vince did make one explicit reference to how, in science, nothing can ever be known for sure and also how "nothing is perfect" in the real world (Vince, Classroom Observation 12). The inclusion of tentativeness, as communicated in his classroom practice, was thus infrequent and not congruent with what would be labeled an informed conception.



Regarding SI, she commented that the ideas behind scientific inquiry foremost include that there is no one correct way to perform an investigation. All investigations start with a question, goal, or purpose, but then there may be many different ways to arrive at a conclusion. Alternatively, it is also possible for different groups to perform the same set of procedures and not necessarily reproduce the same results. Many different sets of data can then be brought together and compared. Any conclusions and interpretations must be consistent with the data.

2.8 Traditional Method of Learning (Lecture Method)

This is a method of teaching that emphasizes “talk- chalk” in the teaching of science subjects more than 80% of scientific information, ideas, concept generalization and facts are verbally presented to students by the teachers (Shittu, 2012). The objective is to stuff the students with information (Shittu, 2012). The teacher does much of the activity in form of talking while the students are either passive or slightly involved.

However, Shittu (2012) stated that, two teaching skills that make lecture method effective are:

i. Clear and good command of language and

ii. Ability to write clearly and boldly on the chalkboard.

In its true nature the lecture approach is not effective for science teaching because it does not promote meaningful learning (James, 2000). While Olarewaju (1994) sees learning through lecture method as pure teacher centered approach where students are not given opportunity to ask questions or give feedback to the teacher. Here, the teacher talks and writes notes on the board while the students listen and copy down and they later study.

The lecture method of learning does not promote academic performance in science as observed by James (2000). But the aspect of relating the method in instruction to students' performance and self-efficacy in biology is an area of study particularly at the NCE level. This study is to determine the effectiveness of learning nature of science in biology using lecture method in relation to performance and self-efficacy at NCE level.

2.9 Concept of Self-efficacy in Education

Self-efficacy is the judgment of one's capability to perform activities within a particular domain which has strong influence on learner achievement (Bandura, 1977). In a related development, Pajares (1996) defined self-efficacy an individual perceived capabilities to attain designated types of performances and to achieve specific results. Based on the above, self-efficacy can be defined as the confidence an individual or a learner exhibit in performing a task.

Learners gain self-efficacy through four sources as enumerated by Bandura, (1997) are: (1) enactive mastery, where the learners master the domain through personal experience, (2) vicarious learning, where the learners gain information through observing

the experiences of other (3) verbal persuasion, in which learners are encouraged by other, and (4) emotional arousal, where the learners develop strong feeling toward the domain.

He went on that out of these four sources of self-efficacy, enactive mastery has the greatest effect on learner self-efficacy. Through personal experiences, learners develop feelings about their ability to accomplish tasks, or self-efficacy, within a particular domain. Past experiences are primary sources of a person's self-efficacy and may be manifested in a learner's poor knowledge of a domain. While poor knowledge impacts academic achievement and self-efficacy (Schunk, 1989), self efficacy acts as a moderating variable between poor knowledge and performance (Pajares, 1996 & Adamu, 2013). On the importance of past experience in learning, Dewey (1966) was of the opinion that teachers must be aware of the past experiences, needs and capabilities of the students.

It seems Self-efficacy can be enhanced as students are engaged in inquiry instructional approach; this because inquiry-based approach encourages self-regulated learning which involve students plan and execute investigation that attracts feedback from teachers. The students design plans which are geared toward solving research questions, they seek for answers and will lead to discoveries. Students become actively involved as researchers, writers, and participants in the classroom (Mollie, C, 2005). The acquisition of these skills and experience of success is expected to enhance students' self-efficacy and understanding of nature of science. Mollie(2005) seems to support this view when he pointed out that inquiry provide high level of self-efficacy in the learner as it promote their versatility, creativity, ownership of their learning, connection to the real world and reinforces multiple skills and allows students to build the confidence to know where and how to get wanted information.

A research was conducted by Adam (2013) in students' self-efficacy and the effect of coaching on a student achievement and creativity. It was concluded that students' achievement were higher in the classroom of students with high learner efficacy. Based on the above, the present study will hopefully be beneficial to NCE students, since they are trained to be teachers and are expected to exhibit self-efficacy in dealing with their students. Debroux (2007) also believed that self-efficacy led to greater achievement and understanding.

2.9.1 Self- efficacy in Science Education

Self-efficacy is the judgment of one's capability to perform activities within a particular domain which has a strong influence on learner's performance (Adamu, 2013). In a related development Abdullahi (2014) defined self-efficacy in time of individual perceived capabilities to attain designated types of performance and to achieve specific result. Self-efficacy would have a prominent impact on behavioral performance and personal confidence level toward an individual's job efficacy (Abdullahi, 2014).

Bandura (1997) cited in Abdullahi (2014) stated clearly in his book that self-efficacy is a key factor in the extent to which learners can bring about significant outcomes in their lives. Specifically, there is considerate evidence to support the contention that self-efficacy beliefs contributed to academic performance by enhancing the motivation to perform. For example Tuckman (1999) has shown that children with the same level of intellectual capability differ in their performance as a function of their level of self-efficacy. Tuckman and Sexton, Tuckman (1999) have reported that the highest Self-efficacy group was found to be 10 times as productive as the low group. Moreover, the high group outperformed their own expectation by 22% while the low group fell below their expectations by 77%. The results reflect a clear relationship between self-efficacy and academic productivity. Many confirmatory studies indicated the significant

aspect of self-efficacy in the learning performance. For example in Liu's (2010) study, a positive correlation between self-efficacy and academic achievement was found. Hsu (2000) also indicated correlation between college student self-efficacy on the subject of biology and learning achievement. Schraw, Crippen, and Hartley (2006) also opined that higher levels of self-efficacy are positively correlated to performance at school and to education in general. Lee (2002) explored the impact of multi-media instruction and self-efficacy on the learning achievement of the participants of physics and chemistry for senior high school students and found that the students learning achievements were indeed influenced by self-efficacy. Heather (2013) stressed that inquiry learning instruction encourage learners to be efficacious. He further asserted that individuals who have a high sense of self-efficacy for accomplishing a task, work and persist longer when they encounter difficulties, where as those who do not feel efficacious may quite or avoid a task. Evidently, self- efficacy is correlation with both the learners' performance, which is the consequence of the learning instruction employed by the learners. In this study, the effectiveness of structured inquiry learning method on self-efficacy and academic performance of nature of science on biology students will be investigated.

2.9.2 Gender and Understanding of the Nature of Science

Erinosho (2005) pointed out that the main focus of great concern in the field of nature of science in science education is bases and misconception about male and female performance i.e. science is a male enterprise.

Gender-related issues here attracted the attention of many researchers in science education from boys and girls in the secondary schools and likewise tertiary institutions respectively. Many studies have investigated the influence of gender on academic achievement or performance and understanding of nature of science.

Understanding of nature of science is affected by many factors such as motivation, student ability, instructional strategy and the quality of secondary education received, among others. Educational performance according to Abdullah (2013) can be considered to mean the successful outcome of accomplished activities or tasks in educational measurement in relation to accepted standards. Tests are conducted to know the level of understanding of the nature of science of students in sated objectives. Several issues regarding gender and science remain controversial. Bichi (2002) stated that one such controversy is that girls do not like practical work and can't handle the inquiry method. A research was conducted by Diane (2007) and in mixed school to see whether boys or girls differ in the level of their academic performance and understanding of the nature of science. The result shows that both sexes do not differ significantly in academic performance and level of understanding of the nature of science, though male students have slightly higher scores test items that deal with logical reasoning in a related development James (2000) in a research on effects of combining reflective writing with concepts mapping and lecture method on pre-service NCE teachers' attitudes and achievement in biology. He concluded that only few candidates lacked understanding of nature of science right from secondary school which is also related to their performance at NCE level.

Other researchers have reported differently on this issue for example, Afuwape and Oludipe (2008); David and Stanley (2002), Din, Mingi and Ho (2004) Freedman (2002, Sungur and Tekkaya (3003) have provided reports that there are no longer distinguishing difference in the cognitive, affective and psychomotor skill performance of studies in respect of gender. Girls are being encouraged and sensitized into developing positive attitudes to read sciences. In a similar vein, Valanide (1996) did not find differences in how males and females engage in reasoning process. A research report by

Ameh and Dantani (2012) stated that boys and girls are equally better in academic achievement when taught using demonstration method than was used. In academic performance Ayodele (2009) found that there was no significant difference between male and female students in private and public schools. However, in terms of academic performance, Lee and Burkam (1996) have reported that females benefited much more than boys did from laboratory experience. Orabi (2007) also reported that females are outperforming males across a range of subjects. Akinsola (2003) observed that females outperformed males in integrated science at the junior secondary school level. Louis and Mistele (2012) reported that a statistically significant difference was found in the academic achievement scores between males and females by subjects, where females scored higher in Algebra, but males' scores of earth science, physics and biology between males and females, where males scored higher in science subjects. In other study, Olagunju and Balogun (2006) also reported that females in the control classes/group performed better than males in the same group.

According to Levi (2001), teacher plays a vital role in addressing the problem of gender equity in science education. To him, there are three main roles a teacher must play, namely:

i. Ensure provision of equal opportunities and respect for difference in the classroom.

ii. Ensure that boys and girls have the same experience, that is, treat boys and girls equally.

iii. Compensate for gender differences in society.

In this study structured inquiry learning strategy will be used to see if the result will be similar or otherwise to that of other researchers discussed earlier on.

2.9.3 Gender and Self-Efficacy

Gender has been defined as the amount of Masculinity or feminity found in a person, where the normal male has a predominance of ferminity (Adamu, 2013), it has been reported by Bichi (2002) that biological differences existed between a man and a woman but the extend of the differences significance is further rooted in the social and cultural expectations of the two.

Self- efficacy is an important factor that affects/influences both students' academic performance and learners' productivity (Bandura, 1997). In science education therefore, the importance of self-efficacy cannot be overemphasized. This is because students with nature of science self-efficacy tend to work harder to accomplish a given task and be more efficient in using inquiry strategies and management of the working time than students with low nature of science self-efficacy (Heather, 2013). Self-efficacy beliefs vary between individuals and will actually fluctuate within an individual for different task (Abduliahi, 2014) self-efficacy is therefore not static.

The relationship gender and self-efficacy has been a focus of many self-efficacy researches. Studies have shown that boys have advantage over girls opting for sciences (Eta, 2002). Another reason as opined by Becker (1991) were that some teachers asked boys more questions, praises boys for quality work and girls praise for neatness. Lee (2002) was of the opinion that male students receive more praise and criticism than female students. On the above Lakpin (2007) observed that teachers used of improved instructional strategy could take care of some of the identified differences. Ruvikumar and Manimozhi (2011) also reported that the self-efficacy in equipmentation of boys and girls is almost equal among the biological students in Cuddalore. But they offer significantly in their self efficacy in equipmentation with respect to their colleges they are studying.

Researchers such as Dabacker and Nelson (2000), Diane Jass Ketehurt (2007) among others reported that male students at high school and college tend to be more confident than females. In a year-long inquiry-based physics course (Cavallo, Rozman, Lara bee Abd Iskawa, 2001) found significant gender difference in students' science self-efficacy. Male students began the course with significantly higher self-efficacy and ended the course also with higher self-efficacy. However, Britner and Pajares (2006) reported higher science self-efficacy among middle school girls than among middle school boys. Also, in their study on sources of science self-efficacy beliefs of middle students, Britner and Pajares (2006) found that girls reported stronger science self-efficacy than boys did. While Abdullahi (2013) has a different report in science in her research work that boys reported stronger in science integrated science self-efficacy than the girls. This study is design to investigate the impact of structured inquiry learning strategy on self-efficacy and academic performance in number of science using skeletal system of NCE students' to see what the result will be.

2.10 Measuring Understanding of the Nature of Science among Different Groups

In this studies on understanding of science, Miller (1963) in Lederman (2000) revealed that a "sizeable group of high school teachers had less understanding of science than their students", even though the teachers' overall mean score was higher than that of the students. The instrument he used for this study was the Test on Understanding Science (TOUS) developed by Cooley and Klopfer (1961).

Schmidt (1968) replicated Miller's study and drew the same conclusions as Miller. Like in Miller's study, no levels of significance were reported for the observed differences. He further observed that significant gains in the understanding of science were made as students progressed through the science education sequence, and that working scientists scored best on the TOUS; levels of significance were not given though,

he noted the need to seek ways of improving understanding of the scientific enterprise for the in-service teachers and recommended experience in service with scientists instead of more courses in science as a means of improving understanding of the scientific enterprise for the in service teachers. Schmidt also pointed out the need to enquire into how science teachers at all levels could better convey their understanding of science to their students.

Welch and Pella (1967) in Lederman (2000) developed an instrument for inventorying knowledge of the processes of science-the Science Process Inventory (SPI), while seeking validation information on this instrument, Welch and Pella reported that the mean SPI score of a sample of 19 scientists was significantly higher than the mean SPI score of a sample of 16 science teachers, while the mean SPI score of science teachers was significantly higher than that of 1283 high school students. These results were in agreement with those that Schmidt and Miller reported. Also in agreement with Miller and Schmidt, the results of Welch and Pella revealed that some high school students scored higher on SPI than some science teachers. Some science teachers also scored higher than some scientists. The background qualifications of the teachers and scientists relative to each other was however, not stated.

Kimball (1967) in Lederman (2000) observed that researchers who had investigated understanding of the nature of science among high school students had concluded that, for whatever reason, American secondary school students typically had not acquired a valid understanding of what was meant by the nature of science, and that the inference usually made was that science teachers were not teaching the nature of science. Considering the fact that recommendations from such studies usually centered on changes in teacher education progress, Kimball compared three groups of subjects, namely: properly qualified science teachers who were the products of such training

programs; professional scientists with similar background in science as the teachers; and philosophy majors, in terms of their understanding of the nature of science. Using the Nature of Science Scale (NOSS) which was developed in the course of the study as the measuring instrument, and an overall sample of about 419 scientists, 78 science teachers, and 87 philosophy majors. Kimball reported findings which could be summarized as follows:

1. No significant difference was found in the nature of science concept held by scientists and by qualified science teachers with similar academic background, although in seven of the eight sub grouping comparisons of teachers and scientists, the teachers scored higher.
2. Neither experience nor time since graduation may be significantly related to the concept of the nature of science expressed by the population studied.
3. Philosophy majors had a significantly better (.01 level of confidence) understanding of the nature of science than the science majors (scientists and science teachers)
4. No significant difference was observed between science teachers and philosophy majors.
5. The professional scientist group scored lower than the philosophy majors at the .01 level of confidence.
6. Irrespective of school of graduation, the philosophy majors had significantly higher test scores than the science majors.
7. No systematic differences were discovered between scientists and science teachers when their scores on individual items of the NOSS were compared.

In the concluding remarks Kimball noted that while earlier studies had found a severe deficiency among the teachers and had recommended changes in science teacher

education programs, it seemed (from the findings) that if deficiencies existed, they were at least equal for the professional scientists, and that for qualified teachers who were prepared with a major in science, the situation was not so dark as had been reported elsewhere. It was further noted that the significantly higher scores of the philosophy majors suggested that one area of attention might be the inclusion of the study of philosophy of science in the undergraduate preparation of science majors in general and prospective science teachers in particular, with regard to the apparent lack of change in understanding of the nature of science with time or experience, he remarked that this was another argument in favour of influencing students during their undergraduate years, since the concept of the nature of science was fairly well established by the time of graduation from college. He also noted the possibility of including work toward better understanding of the nature of science in teacher in-service training programs.

Broadhurst (1967) in Lederman (2000) administered the TOUS, form W, to a group of 108 senior secondary school chemistry students and their teachers in non-departmental schools in Sydney and reported that when the scores of all the pupils were compared with all the teachers, the teachers' scores were significantly better.

2.10.1 Science Curricula and the Development of Understanding of the Nature of Science

Much research has been carried out with the purpose of evaluating various science curricula particularly in terms of how efficient they were in leading to the development of an understanding of the nature of science.

In 1956, Benjamin Bloom headed a group of educational psychologists who developed a classification of levels of intellectual behavior important in learning. During the 1990's a new group of cognitive psychologists, lead by Lorin Anderson (a formal student of Bloom), updated the taxonomy to reflect relevance to 21st century work. The two graphics in the appendix show the revised and original taxonomy. This is evidence

that point out that understanding is one of the new classifications of levels of intellectual behavior where the students can explain ideas or concepts using such words as classify, describe, discuss, explain, identify, locate, recognize, report, select, translate, paraphrase.

Mackay (2001) in Heather (2013), used form W of TOUS to measure some of the changes that occurred in students' understanding of the nature of science as they studied integrated science courses in grade 7 to 10 in Victorian high schools in Australia. A total of 1556 students were tested on the first occasion which was at the beginning of the 1968 school year, while 1203 students were tested on the second occasion, which was at the end of the 1968 school year. Mackay reported that there was no improvement in the probability of correctly answering items on TOUS from the first to second testing in respect of males in grade7 and females in grades 7, 8, 9, and 10. She also reported that the proportion of students correctly answering in the grade 10 group on the majority of items. Mackay further identified a number of common deficiencies in students understanding of the nature of science among which were a "lack of appreciation" of the functions of scientific models; the roles of theories and their relationship to research; the distinctions between hypotheses, laws, and theories; the difference between science and technology.

Tamir (1972) in Heather (2013), used the Science Process Inventory (SPI) to evaluate the level of understanding of the processes of science by high school students exposed to different science curricula in Isreal. Using a total sample of 3,500 students in 9^{th}, 10^{th}, 11^{th}, and 12^{th} grades from all types of Isreali high schools, Tamir established norms for these grades of students in Isreal with the SPI as a measure of understanding of the processes of science. Tamir also identified major misconceptions of Isreali high school students regarding the nature and processes of science. His studies further revealed that students in occupational schools were at a disadvantage compared with students in other types of school regarding their understanding of the processes of science, and noted

that this “may be a result of the more conventional nature of occupational schools which place high premium on stable factual knowledge”.

2.10.2 Instruments for Measuring Understanding of the Nature of Science

From all the above cited instances of current research into understanding of the nature of science, it would be noticed that three instruments have been mentioned, namely:

1. The Test on Understanding Science (TOUS) developed by Cooley and Klopfer (1961)
2. The Science Process Inventory (SPI) developed by Welch and Pella (1967).
3. The Nature of Science Scale (NOSS) developed by Kimball (1967)

Of these three instruments, the TOUS was the earliest and most popular in use, followed by the SPI. However, the NOSS was adapted for use in the present study rather than the other two for the following reasons:

1. Many doubts have been expressed as to the validity and reliability of the TOUS. (Ramsey and Howe, 1969), (Welch, 1967), (Tamir, 1972).
2. The NOSS has fewer items on it than the TOUS or SPI, making for easier administration and scoring.
3. The NOSS seems to have developed with a bias for measuring understanding of the nature of science among graduate level subjects, because, validity and reliability information on NOSS were based on pilot tests on graduate level subjects. On this basis the NOSS may be more suitable for measuring understanding of the nature of science among graduate level subjects (as required by this study) than the TOUS or SPI.

4. The declaration which formed the model of the nature of science on which the items on the NOSS were based showed agreement with the model of the nature of science as drawn up in the literature review of this paper.

2.11 Overview of Similar Studies

Numerous studies reveal mixed result with regard to instructional strategies, students' self-efficacy and understanding of the nature of science in general and as they specifically relate to gender differences/gap. Such studies include the following among others:

The National Research Council (NRC, 2000) pointed out that inquiry environment can best facilitate focusing on learning the developing of certain scientific concepts. However, if students under the teachers' guidance focus their attention on the content they have less suitable means for discovering scientific thinking, process and gaining experience (Kai, & Krajak, 2006). Liang and Richardson (2009) have reported the positive effects that inquiry-oriented science learning and teaching have on pre-service teachers understanding of the nature of attitudes and beliefs about science learning and teaching and their classroom teaching performance it has also been reported that students who enrolled in inquiry-based science classes met cognitive facilitation (NRC, in Liang and Richardson, 2009). In structured inquiry learning method the teachers and learners play a crucial role in asking questions, developing answers and structuring of materials and cases. The usage of structured inquiry learning strategy is very important in transition from lecture method to other activity based methods which are less and more clearly structured for alternative solution (Bilgin 2007).

Diane (2007) examines the use of structured inquiry teaching and learning method in Senior high school to determine the effects of structured inquiry method on students in biology. He used Forty six (46) biology students (Boys and Girls) in senior secondary

school two (SS II) from two randomly selected schools. The data collected were analyzed using t-test statistics at a significant level of 0.05. The results revealed that students performed better in better in biology when taught using demonstration as compared to the lecture method. Also, boys and girls are better in academic performance when taught using inquiry method than when lecture method was used.

Alake and Ogunemi (2013) assessed the effects of scaffolding strategy on the academic achievement of student in integrated science in the junior secondary school (jss). The instrument used was the Integrated Science Achievement Test (ISAT) and t-test statistics was used in analyzing the result. The results showed that students exposed to scaffolding strategy performed significantly better than their counterparts who were exposed to lecture method.

Akinsola (2013) investigated the relative effectiveness of mastery learning, cooperative learning, and combined mastery learning and cooperative learning strategy on students' achievement in integrated science. The subjects consisted of two hundred (200) JSS students. Analysis of covariance (ANCOVA) and the Duncan Post-hoc analyses were used in analyzing the data collected. The results revealed that combined mastery learning and cooperative learning strategy was found to be suitable in facilitating achievement in integrated science in the JSS. Females outperformed males in integrated science at the JSS level and this may be due to the home activities females are engaged in such as cooking, sweeping, washing, e.t.c.

Louis and Mistele (2012) examined the difference in scores and self-efficacy by students' gender in mathematics and services. They were able to demonstrate that there is a statistically significant difference in the academic scores in Earth science, physics and biology between males and females where males scored higher in science subjects. In both mathematics and science examination they controlled for self-efficacy where in

mathematics females hold lower self-efficacy than males and in science there is no difference between females and males in terms of self-efficacy. They concluded that mathematics and science classrooms that consider self-efficacy may impact students' achievement scores by subjects.

Hattie (2009) In synthesis of two model of "inquiry-based teaching found that this approach resulted in improved student performance in a number of areas. Increased the amount of time students spent in labs, decreased teacher led discussions in classrooms and also improved critical thinking. Likewise Shymansky, Hedges, and Woodsworth (1990) found that this approach helped students gain greater competencies in scientific process and improve students' self-efficacy than single model of inquiry.

Tenaw (2013) investigated the level of students' self-efficacy and academic achievement in male and females of second year students in the fall of 2012 in Analytical chemistry l (ACl) at Debre Markos college of Teacher Education. He used a sample of 100 students' self-efficacy questionnaire and ACl achievement test were used as the instruments of the study. The difference of self-efficacy and achievement was calculated using t-test and the relationships between self-efficacy and achievement was investigated using Pearson correlation. The results indicated that students' level of self-efficacy is medium and there is no significant difference in their self-efficacy in the sexes. But, there is a statistically significant difference in achievement in the sexes. Also, a significant relationship exists in self-efficacy and achievement. This may be due to due to the fact that the sampled subjects were exposed to the same treatment (i.e. inquiry strategy) and it will help the researcher to assess the relationship in level of efficacy of male and females when exposed to structured inquiry strategy.

Adamu (2013) investigated the effects of problem-solving instructional strategy on NCE students' self-efficacy, creativity and Academic Achievement in Genetic. He

used a sample of 100 students. Genetic Achievement Test (GAT) Genetic Achievement Test (GAT) and Ibadan Creativity Assessment Scale (ICAS) were used as the instrument of the study. The difference of self-efficacy achievement, creativity was calculated using t-test. The results indicated that students exposed to problem solving instructional strategy have level of self-efficacy, performance and creativity than their counterpart exposed to lecture method. The concern of the present study is to investigate the impacts of structured inquiry in structured inquiry instructional strategy on NCE Biology students' self-efficacy and academic achievement on nature of science using skeletal system concepts.

2.12 Implications of Literature Review for the Present Study

The literature reviewed was on the impact of structured inquiry instructional strategy on self-efficacy and understanding of nature of science among NCE students.

An attempt has been made in this review to discuss the nature of science using cell biology concept with particular reference to the impact of inquiry instructional strategy and other related teaching and learning methods and strategies. Heather (2013) opined that inquiry encourages good learning habit, logical thinking and promote intellectual development and understanding of nature of science. On the area of academic performance Lederman (2012), Diane (2007), Shittu (2012), Usman (2011), and Gumel (2015) in their various studies have shown that inquiry instructional strategy is superior to other learning and teaching methods and strategies compared and developed self-confidence in learners. On literature reviewed on self-efficacy, Diane (2007) believed that self-efficacy enhanced self-confidence in learners and led to greater achievement or performance. The structured inquiry instructional strategy therefore has implication on the present study in the sense that majority of the researchers have been working on effect of inquiry on students academic achievement or performance but this study is focusing on

the impact of inquiry on students understanding and self-efficacy, secondly from the five steps of inquiry strategy of Heather,(2013) and the seven steps of inquiry strategy of Lederman (2000), this study also has seven steps of structured inquiry strategy which is an innovation of Heather (2013) and Lederman (2000) that is more precise and straight forward in learning nature of science. Thirdly from the twenty nine nature of science item of Abah (1979), this study has forty natures of science statement items that can be use in quantifying students understanding of nature of science.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

In this chapter, the methodology used for data collection is described. Specifically it is presented under the following sub-headings;

3.2 Research Design

3.3 Population of the Study

3.4 Sample and Sampling Procedure

3.5 Instrumentation and Validation

3.6 Item Analysis

3.7 Pilot Testing

3.8 Validation of the Instrument

3.8.1 Reliability of the Instrument

3.9 Administration of Treatment

3.10 Data Collection Procedure

3.11 Procedure for Data Analysis

3.2 Research Design

This study is an experimental design which adopted the pretest-posttest experimental control groups design. This study is experimental because the researcher has no total control of the study subjects. The illustration of the design for this study is presented below:

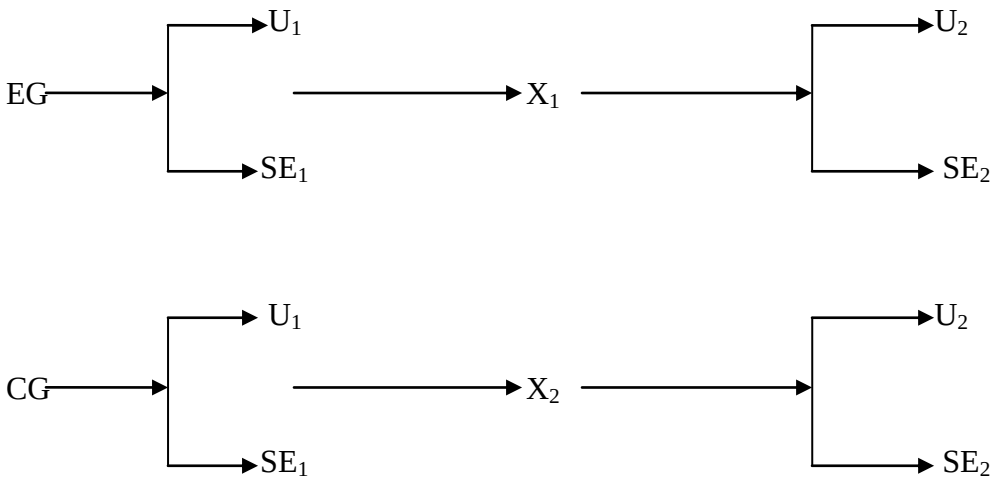


Fig. 3.1: Design of the Study

Where EG = Experimental Group

CG = Control Group

U_1 = Understanding (Pretest)

U_2 = Understanding (Posttest)

SE_1 = Self-Efficacy (Pretest)

SE_2 = Self-Efficacy (Posttest)

X_1 = Structured Inquiry Instructional Strategy

X_2 = Lecture Instructional Method

3.3 Population of the Study

The population for the study comprises of all the NCE 1 biology students of the three State Colleges of Education in Kwara State with the population of two thousand two hundred and seven NCE I biology students out of which males were one thousand and seven while females were one thousand two hundred students respectively. The distribution of the population is presented in Table 3.1.

Table 3.1: The Study Population

S/N	Name of Institute	Location	Male	Female	Total
1	College of Education (Technical) Lafiagi (COET)	Lafiagi	292	323	615
2	College of Education IIorin	IIorin	396	456	852
3	College of Education Oro	Oro	319	421	740
Total		Three	1007	1200	2207

Source: The Examination Officers of the Colleges of Education (2015)

The three State Colleges of Education are co-educational. All the students offer biology with other science subjects like Biology/Chemistry, Biology/Computer Science, Biology/ Integrated Science among others. The students were within the age range of 19-22 years and majority of the students were from the listed tribes Yoruba, Nupe and Baruba. Cell biology is one of the concepts offered by biology students in BIO112 at NCE I level.

3.4 Sample and Sample Procedure

In this study, table of randomization was used. This is to avoid the researcher being bias in selecting the schools and their populations. The researcher employ table of randomization to select the two schools that was used as experimental and control groups. To select the schools the researcher assigns number to the schools as odd number and even number while the odd numbers stand to be the selected sample. The two schools picked from the table of randomization were 1 and 3 which were randomly assigned as experimental group, and control group.

The students selected as experimental group in this study were two hundred and four and the selected students for the control group were two hundred and eighty four while those students not selected form another group handled by other lecturers of the colleges. This selection was done on the basis of the school tradition as the school always

divides each year level into three groups with different lecturers handling them and this is because of the large number of the students in the department.

Forty five students were selected out of the two hundred and four students in experimental group while forty five students were also selected from the control group out of population of two hundred and eighty four using table of randomization. The students in experimental group were assigns to numbers from 000 to 204 on the table of randomization and any number that falls within the forty five i.e. 001 to 045 were selected. The researcher also assigned numbers to control group on table of randomization from 000 to 284 and any number that falls within forty five i.e. 001 to 045 were selected. The researcher then allowed the rest of the students not selected to be handled by the lecturer the group was initially assigned to. This sampled size is in line with the Central Limit Theorem. Tuckman (1975) stated that sampled size of minimum of 30 subjects is viable for Experimental study of this nature. The composition of the subjects selected from colleges is shown in Table 3.3.

Table 3.2: Sampled Subjects

S/N	Name of the Groups	Male	Female	Total
1	**Experimental group**	**19**	**26**	**45**
2	Control group	22	23	45
Total	2	41	49	90

3.5 Selection of Concepts Taught

The concept cell biology was selected from Biology curriculum for NCE1 students with attention on the followings:

1. Diffusion in living organisms;
2. Factors affecting diffusion;
3. Osmosis in living organisms;

4. Differences between diffusion and osmosis.

The choice of this concept was not because students fail it but because it is a concept that provides minds on and hands on activity in the classroom setting that can provides them with the believe of scientific way of thinking.

The concept cell biology is taught right from the junior secondary school to senior and up to tertiary level, as such; the students' performance in it does not really reveal the understanding of the concept to the learner. In addition, Udodo Umeh (2006) stated that students find these concepts cell biology difficult earlier at the basic study because they do not understand the basic principles of manipulation in it or the teaching instruction employed by their teachers is not appropriate.

3.6 Instrumentation

The instruments for data collection in this research are:-

1. Nature of Science Understanding Test (NOSUT) and
2. Nature of Science Self-Efficacy Questionnaire (NOSSEQ)

3.6.1 Nature of Science Understanding Test (NOSUT)

Due to inherent difficulty of instrument construction and lack of time and funds to embark upon such a project, a new instrument could not be constructed for the purposes of the study. However, from the review of literature an instrument considered suitable for use in this study was discovered and adapted.

Of the three instruments in common use for this type of study as revealed by the available literature, namely; Test on Understanding Science (Cooley and Klopfer, 1961); Science Process Inventory (Welch and Pella, 1967); and Nature of Science Scale (Kimball, 1967), the Nature of Science Scale (NOSS) was adapted from Abah (1979) for use in this study. The reasons for adapting the NOSS rather than the other two were given under the literature review in chapter 2 and during the process of adapting it the title of

the instrument was changed from Nature of Science Scale to Nature of Science Understanding Test.

Nature of Science Understanding Test (NOSUT) adapted from Abah (1979) was used to measure students' Understanding in scientific method. It was 40 items statement about the characteristics of scientists with options of "True" or "False".

The NOSS was initially 29 items while the NOSUT is 40 items whereby 11 additional items were added.

3.6.2 Scoring the Instrument

The scoring pattern for items on the NOSS as used by Abah was "2 points for each response in agreement with the model, 1 point for a neutral response, and 0 point for a response opposite to the response predicted by the model". But, the present study noted the reservation about such scoring pattern:

1. Awarding 1 point for a neutral response may lead to awarding too many points to those who may be really ignorant of the item.

For the sake of this study, the items on the NOSUT were scored as follows: 1 point for a correct response that agreed with the model, and 0 points for an incorrect response opposite to that predicted by the model. Thus, the respondents will be required to indicate whether the statement is "True" or "False" with the items on the NOSUT with no obvious provision for neutral responses. This measure was thought to be capable of increasing or sharpening the discriminating power of the instrument. A copy of the NOSUT as used for this study can be seen in Appendix

3.6.3 Validation of the Instrument (NOSUT)

For Nature of Science Understanding Test (NOSUT) and corresponding response to the model were given to three Senior Lecturers in Science Education Department, ABU. Zaria with PhD in Science Education and Two Chief Lecturers from Colleges of

Education with at least Masters degree that validated the instruments. Those involved in the validation were requested to critically examine and asses all the items of the instrument paying attention to the following:

i. whether the questions are clear, precise and free from ambiguity;

ii. Whether the level of difficulty of the questions match the ability of students

The experts made constructive criticisms in area of language level and content area of the (NOSUT) instrument and the corrections were effected.

Nature of Science Understanding Test (NOSUT) was pilot tested using forty five 2015/2016 N.C.E. I Biology students of Kwara State College of Education Oro immediately after completion of the Topic physical processes of cell (osmosis and diffusion) Concepts in the course Bio 112.

3.6.4 Nature of Science Self-Efficacy Questionnaire (NOSSEQ)

Nature of Science Self-Efficacy Questionnaire (NOSSEQ) was adapted by the researcher from (Heather, 2013). It was a 20 items statement about the student conviction in doing things related to nature of science in cell biology in the area of methods, analysis, experimenting and drawing conclusions. In the process of adapting, the title of the instrument was changed from Science to Nature of Science Self-Efficacy Questionnaire (NOSSEQ) and initially it was 11 items so the researcher added additional 9 items to make it 20. By the end of the exercise, the data were collected and was subjected to statistical analysis.

3.6.5 Scoring Pattern of the Instrument (NOSSEQ)

The subjects were assessed using a linkert scale 4-1 of strongly agree, agree, disagree and strongly disagree where strongly agree was scored as 4 points, agree as 3 points, disagree as 2 points and strongly disagree as 1ponit.

3.6.6 Item Analysis

Item analysis is a process which examines student responses to individual test items (questions) in order to assess the quality of those items and of the test as a whole. Item analysis is especially valuable in improving items which will be used again in later tests, but it can also be used to eliminate ambiguous or misleading items in a single test administration.

Item Difficulty or the difficulty of an item is defined as the number of students who are able to answer the item correctly divided by the total number of students.

Difficulty Index: Difficulty Index (D.I) of the NOSUT was calculated using the conventional approach that is Good Upper (U) + Good Lower (L) divided by the total Number of Subjects (N) (U+L/N). two sub-groups were extracted from the sample, the high scorers U (Upper) and the low scorers L (lower group), the distribution of persons is treated as normal as suggested by Kelly, (2005). The D.I of NOSUT is as follows:

- Items with D.I ranging from 0.50 to 0.70 were accepted without modification.
- Items with D.I from 0.80 to 0.90 were accepted and retained.
- Items with D.I of 0.40 and 1.00 respectively were discarded and replaced because the former were considered too simple since most students got the answers right.

Discriminating Index: the Discriminating Index (DC.I) of a test item is a measure of its ability to discriminate between high and low ranks in the test as a whole (Bichi, 2002). The DC.I of the test items were clearly calculated within the required limits and are consisted with Tristan, (1995) where it was recommended that most items DC.I should be in the range of 0.0 to 0.3, with no index greater than 0.9 which would mean that the item was too easy for almost the entire set of examinees.

3.6.7 Validation of the Instrument (NOSSEQ)

Nature of Science Self-Efficacy Questionnaire (NOSSEQ) was given to three Senior Lecturers in Science Education Department, ABU. Zaria with PhD in Science Education and Two Chief Lecturers from Colleges of Education with at least Masters degree who validated the instruments. Those involved in the validation were requested to critically examine and asses all the items of the instrument paying attention to the following:

i. whether the questions were clear, precise and free from ambiguity;

ii. Whether the questions measures what is intended to be measured;?

The experts made constructive criticisms in area of language level and content area of the (NOSSEQ) instrument and the corrections were made.

Nature of Science Self-Efficacy Questionnaire (NOSSEQ) was pilot tested using forty five 2014/2015 N.C.E. I biology students of Kwara State College of Education, Oro immediately after completion of the Topic cell biology concepts in the course BIO 112.

3.7 Pilot Testing

The two instruments NOSUT and NOSSEQ was pilot tested using 2015/2016 N.C.E. I Biology students of Kwara State College of Education, Oro since the College is part of the population but not part of the sample.

The pilot study was carried out with forty five Biology Students immediately after completion of the topic cell biology concept in BIO 112 using Nature of Science Understanding Test (NOSUT) and Nature of Science Self-Efficacy Questionnaire (NOSSEQ) instrument respectively. Table of randomization was used in selecting the forty five students. This is to avoid the researcher been bias in selecting his subjects.

On NOSUT: The forty (40) items instrument was administered to thirty (30) students with the assistance of the Biology lecturers of the College which lasted for one

hour. The students were pretested by giving them question paper containing intended test and task to be carried out. After two weeks, the post test was administered to the subjects. The test–retest method of two weeks in line with Tuckman, (1975) was employed and Pearson Product-Moment Correlation Coefficient (PPMCC) was used to determine the reliability.

On NOSSEQ: The twenty (20) items instrument was administered to thirty (30) students with the assistance of the Biology lecturers of the College which lasted for thirty minutes. The students were pretested by giving them question paper containing intended test and task to be carried out. After two weeks, the post test was administered to the subjects. The test–retest method of two weeks in line with Tuckman, (1975) was employed and Pearson Product-Moment Correlation Coefficient (PPMCC) was used to determine the reliability. Both the NOSUT and NOSSEQ were administered within a day. The result of pilot study Find is in appendix.

3.7.1 Reliability of the Instrument (NOSUT)

Reliability is the degree to which a test on repeated measurement yields almost the same result when administered to subjects of similar characteristics (Sambo, 2005 & Adamu, 2013). To determine the reliability of the instrument (NOSUT) test-retest method was employed. The test was administered to NCE I Biology Students of Kwara State College of Education, Oro which was outside the sampled area. The instrument was administered twice with the interval of two weeks as proposed by Tuckman (1975).Pearson Product Moment Correlation Coefficient statistics was used for analysis. The reliability coefficient of Nature of Science Understanding Test (NOSUT) was determined to be 0.96.

3.7.2 Reliability of the Instrument (NOSSEQ)

To determine the reliability of the instrument (NOSSEQ) test-retest method was employed. The test was administered to NCE I biology students of Kwara State College of Education, Oro which was outside the sampled area. The instrument was administered twice with the interval of two weeks as proposed by Tuckman (1975). Pearson Product Moment Correlation Coefficient statistics will be used for analysis. The reliability coefficient of Nature of Science Self-Efficacy Questionnaire (NOSSEQ) was determined to be 0.79.

3.8 Structured Inquiry Learning Cycle Model

The structured inquiry learning cycle model Task, Engagement, Understanding, Experimentation, Explanation, Inference and Communication (TEUEEIC) was adapted from Heather (2013) and Lederman (2000). Heather (2013) inquiry model was five steps inquiry pattern as Observation, Collecting data, Understanding the data, Experimenting and discussion of the result (OCUED) and Lederman (2000) six steps inquiry model include Initiation of the Problem, Engagement of students, Experimentation, Explanation, Inference and Communication (IEEEIC). The researcher seven steps of structured inquiry learning cycle model were more precise in nature. It is an instructional model of learning in which the learners build new ideals on understanding of nature of science. Each of the letters describes a phase of learning. Each letter stands to mean T-task, E-engagement, U-understanding, E-experimentation, D-Discussion, I-inference and C-communication (TEUEDIC). The seven words listed can be used with students of all levels of education. It allows students and teachers to experience common activities, to use and build on prior knowledge and experience, to construct meaning, and to continually asses their understanding of a concept.

The structured inquiry seven steps lesson Planning Model is illustrated on a flow chart as follows:

The Seven Structured Inquiry Model

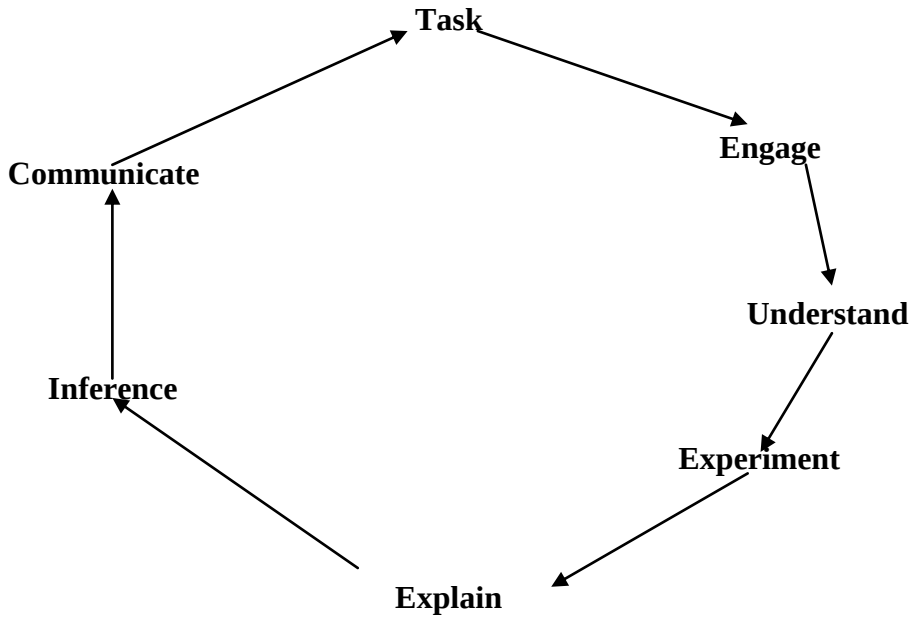


Fig. 3.2: Flow Chart of Structured Inquiry Instructional Strategy Steps Adapted from Heather (2013), and Lederman (2000)

1. In the task phase teacher initiate the problem to the students based on the objectives set for that topic.
2. In the engagement phase students make connections between past and present learning experience.
3. Understanding phase focuses on students' thinking of how to go about the task given to them and how effective can they execute it.
4. Experimentation phase, here students try to explore their environment or manipulate materials. This phase enables the students to acquire adequate knowledge of the science concepts taught to them.
5. The explanation phase helps students explain the concept they have been exploring.

6. The Inference phase helps students to summarize in conclusive form about their findings.
7. Communication phase which mark the end point gives students opportunities to express their conceptual understanding of the investigation and improves their scientific skills.

3.8.1 Administration of Treatment

The pretest was first administered to the subjects to assess their level of understanding about the nature of science. Then the treatment was administered to the NCE I Biology students in the two Colleges of Education sampled in Kwara State using structured inquiry instructional strategy adapted from Heather (2013) and Lederman (2000).

The treatment administered to the study subjects involves teaching Cell Biology concepts which includes physical processes of cell such as diffusion and osmosis. The students were guided by the researcher on definition of cell, types of cell, structural and functional characteristics of cell, defining diffusion, and explaining diffusion in living organisms, defining osmosis, and explaining osmosis in living organisms. The samples were classified into experimental and control groups.

This study was based on TEUEDIC cyclic model in inquiry based teaching which was adapted from Heather (2013) and Lederman (2000). A lesson note was prepared on each topic for a teaching period of 60 minutes per lesson for each group; which amount to a total period of one hundred and eighty minutes (the lesson notes are presented as appendix). However, each group had three lessons over a period of three weeks. The lesson was taught to each group during school hours to enable all the study samples to participate actively in the study. The subjects in each group had a contact session of one time per week. The researcher personally taught only the experimental group while the

control group was taught by their lecturer since they were taught using lecture method which they are used to. The same apparatus, contents and evaluation questions was used throughout the lessons. This is to ensure that any differences in students' understanding and self-efficacy levels was attributed only to structured inquiry method that is use.

After the three weeks of teaching, a post-test was given to all the two groups in the two colleges. The students' scores on Nature of Science Understanding Test and Nature of Science Self-efficacy Test were recorded and these form the data for testing the stated hypotheses.

3.8.2 Treatment Procedure for Experimental Group

The experimental group lesson was based on the seven steps of structured inquiry learning model as explained below.

PHASE 1 Task: The teacher initiated the task and introduced it to the students' based on the concepts learned.

PHASE 2 Engagement: The teacher provided the materials that were used by the students. This lay the ground work for their tasks.

PHASE 3 Understanding: The students tried to depict meaning to the task ahead of them by analyzing the procedural leaflets given to them on how to execute the task successfully.

PHASE 4 Experimentation: The students carried out the investigation following the procedure given to them.

PHASE 5 Explanation: The students tried to explain their findings based on their observations and investigation. They tried to tell the teacher what they saw during the investigation.

PHASE 6 Inference: The students tried to summarize in conclusive form about their findings.

PHASE 7 Communication: The students expressed their conceptual understanding of the investigation to their teacher for justification.

The subjects were taught cell, types of cell, characteristic features of cells, physical processes of cell such as diffusion and osmosis.

3.8.3 Teaching the Control Group

The control group was also taught the same concepts by the assistant of biology lecturer in that school for three weeks using lecture method. The detail procedures of the lesson plan for the control group are in the Appendix.

3.9 Data Collection Procedure

The study involves the use of two groups. Table of randomization was used in selecting two colleges of education out of the three colleges of education in kwara state, Nigeria. The subjects were pretested using the instruments Nature of Science Understanding Test (NOSUT) and Nature of Science Self-Efficacy Questionnaire (NOSSEQ) to establish their self-efficacy and understanding to see if they are equivalent or not before exposing them to the treatment. Structured inquiry instructional strategy was used on the experimental group while lecture method was used on control group and they were post tested using the same instruments to determine whether the treatment had any impacts on the subjects or not.

After teaching the experimental and the control groups for period of three weeks, a post test using Nature of Science Understanding Test (NOSUT) and Nature of Science Self-Efficacy Questionnaire (NOSSEQ) were administered by the researcher. The NOSUT was marked and scored over 40 and each correct response attracted one mark, the NOSSEQ was marked and scored over 20. After marking the scripts of the NCE I biology students, the scores were recorded accordingly based on experimental group as well as control group. The test lasted for one hour thirty minutes. That is 60 minutes for

NOSUT and 30 minutes for NOSSEQ based on pretest duration. The data collected were subjected to statistical analysis.

3.10 Procedure for Data Analysis

The collected data was used to answer the research questions and test the stated hypotheses as stated in chapter one. In answering research questions, descriptive statistics in form of Mean ($\bar{X}$) and Standard Deviation (SD) was used while the t-test statistic was used to find out the difference among the subjects and the Pearson Product Moment Correlation Coefficient (PPMC) was used to find out the relationship among the subjects.

The analysis of data for the study was based on data collected. Probability level of $P \leq 0.05$ was set for retaining or rejecting the null hypotheses. The scores obtain from the (NOSUT) provided data for testing hypotheses 1-4.

The stated hypotheses along with the suitable statistical analysis used were as follows:

$H_{O1:}$ There is no significant difference in mean scores in NOSUT by NCE I Biology students taught cell biology using inquiry method and those taught using lecture method. To analyze the data, statistical tool t-test was used to determine whether there is a significant difference between the post test understanding of nature of science for both experimental and control groups at $P \leq 0.05$ level of significant.

H_{O2}: There is no significant difference in the mean scores in the NOSSEQ of NCE I biology students' taught cell biology concepts using inquiry instructional strategy and those taught using lecture method. Mann-Whitney U-test statistic was used to analyze the post test scores for both experimental and control groups at $P \leq 0.05$ level of significant.

H_{O3}: There is no significant difference in self-efficacy and understanding of nature of science by male and female NCE I biology students taught cell biology using inquiry instructional strategy. To analyze post test understanding of nature of science between male and female in experimental groups, t-test was used at $P\leq 0.05$ level of significant.

H_{O4}: There is no significant relationship between NCE Biology students understanding of nature of science and their self-efficacy after exposure to inquiry instructional strategy. For this hypothesis, Pearson Product Moment Correlation Coefficient (PPMC) statistical tool was used to analyze the post tests of understanding nature of science within the experimental group at $P\leq 0.05$ level of significant.

CHAPTER FOUR

ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

In this chapter analysis, result, summary of findings and discussions were presented. The results are presented according to the sequence of the research questions and hypotheses which guided the study. The data for the study were analyzed using the statistical package for social sciences (SPSS). The data were generated using two instruments: Nature of Science Understanding Test (NOSUT) and Nature of Science Self-efficacy Questionnaire (NOSSEQ).

The scores obtained were used to measure the impacts of the structured Inquiry-based instruction on the learners' self-efficacy and understanding of nature of science in cell biology concepts. The results are used to answer the research questions and testing the null hypotheses. The level of significance adopted for retaining or rejecting each of the null hypotheses is $P \leq 0.05$. The chapter is presented in the following sub-headings:

4.2 Analysis and Result Presentation

4.3 Summary of the Findings

4.4 Discussion

4.2 Analysis and Result Presentation

The data collected for the purpose of this study was analyzed based on the research questions and hypothesis formulated.

Research Question 1: What is the difference in understanding of nature of science by NCE I Biology students exposed to inquiry instructional strategy and those taught using lecture method?

The data collected for the purpose of answering research question one was analyzed using descriptive statistics in form of mean and standard deviation as shown in table 4.1a.

Table 4.1a: Mean Scores and Standard Deviation in NOSUT of the Experimental and Control Groups

Group	N	Mean	S.D	Mean diff
Experimental	45	32.13	7.13	
				15.49
Control	45	16.64	4.15	

Table 4.1a shows that there is a difference between the experimental and control groups. Table 4.1a revealed that understanding Nature of science of NCE Biology students was statistically lower in the control group (16.64, ±4.15) as compared to those in the experimental group (those taught using inquiry instruction strategy) (32.13 ± 7.13). This implies that there is a higher understanding of nature of science by NCE Biology students when taught using inquiry instruction strategy.

HO_1: There is no significant difference in mean scores in NOSUT by NCE I Biology students taught cell biology using inquiry method and those taught using lecture method. The HO_1 was analyzed using t-test statistic at $P \leq 0.05$. The result is presented in Table 4.1b.

Table 4.1b: t-test for Difference in the understanding of the nature of science in NCE I Biology Students taught cell biology using Inquiry method and those taught using lecture method

		N	Mean	Std. Dev.	Df	t-cal	p-value	Remark
Pair 1	Experimental	45	32.13	7.132				
					166	11.20	.000	Sig.
	Control	45	16.64	4.154				

Significant at $P \leq 0.05$

The result in Table 4.1b reveals that the t-value calculated is 11.20 and the p-value observed is 0.00 at degree of freedom (df)=166. Since the p-value observed (0.00) is less than the $P \leq 0.05$, it means that there is a significant difference in the mean scores of the experimental and the control groups. The significant difference is in favour of the

experimental group exposed to structured inquiry teaching method as indicated by the mean scores. Therefore the null hypothesis which states that there is no significant difference in the mean scores of NCE Biology students' level of understanding of nature of science of the two groups is therefore rejected.

5. **Research Question 2**: What is the difference in self-efficacy of NCE I Biology students exposed to inquiry instructional strategy and those exposed to lecture method? For the purpose of answering research question two, the data collected is analyzed using descriptive statistics in form of Mean and Standard Deviation as presented in Table 4.2a

Table 4.2a: Mean Scores and Standard Deviation in NOSSEQ of the Experimental and Control Groups

	N	Mean	S.D	Mean diff
Experimental	45	49.71	9.932	
				48.21
Control	45	1.50	.503	

Table 4.2a revealed that self-efficacy between NCE Biology students was statistically lower in the control group (1.50 ± .503) as compared to those in the experimental group (49.71, ±9.93). This implies that there is a higher self-efficacy of NCE Biology students when taught cell biology using inquiry instruction strategy.

H02: There is no significant difference in the mean scores in the NOSSEQ of NCE I biology students' taught cell biology concepts using inquiry instructional strategy and those taught using lecture method.

The $H_0 2$ is analyzed using U-test statistic at $P \leq 0.05$. The result is presented in Table 4.2b.

Table 4.2b: Mann-Whitney U for Difference in the mean scores in self-efficacy in NCE Biology Students taught cell biology using Inquiry instructional strategy and those taught using lecture method

	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Z	p-value	Remark
Experimental	45	66.96	3013.00	47.000	-7.797	.000	Sig.
Control	45	24.04	1082.00				

*Significant at P≤0.05

Table 4.2b shows that, the calculated p value of 0.000 is less than the 0.05 alpha level of significance and the calculated Mann Whitney U value of 47.00 is higher than the Z value of -7.797. Their computed Mean Rank efficacy scores were 66.96 and 24.04 by students taught cell biology using inquiry instructional strategy and those taught using lecture method respectively while their computed sum of Rank scores are 3013.00 and 1082.00 by students taught cell biology using inquiry instructional strategy and those taught using lecture method respectively. This implies that significant positive effect exist in their mean attitude rank as a result of teaching cell biology with inquiry instructional strategy. Therefore the null hypothesis which states that there is no significant difference in the mean scores in self-efficacy between NCE biology students' taught biology concepts using inquiry instructional strategy and those taught using lecture method is therefore rejected.

6. **Research Question 3:** What is the difference in self-efficacy and understanding of nature of science by male and female students after exposure to inquiry instructional strategy?

For the purpose of answering research question three, the data collected was analyzed using descriptive statistics in form of mean and standard deviation as presented in Table 4.3a.

Table 4.3a: Mean Scores and Standard Deviation in NOSSEQ and NOSUT of Males and Females in the Experimental Group

	N	Mean	Std. Dev.	Mean diff
Male	19	31.53	3.65	
				1.05
Female	26	32.58	4.50	

Table 4.3a revealed a slight mean difference (1.05 ± 0.843) with the male (31.53 ± 3.65) slightly statistically lower compared to their female counterparts (32.58, ± 4.50). This implies that there is no statistically difference in self-efficacy and understanding of nature of science between male and female students exposed to inquiry instruction strategy.

H03: There is no significant difference in self-efficacy and understanding of nature of science by male and female NCE I biology students taught cell biology using inquiry instructional strategy.

The H03 was analyzed using t-test statistic at P≤0.05. The result is presented in Table 4.3b

Table 4.3b: t-test for Difference in self-efficacy and understanding of nature of science by Male and Female NCE I Biology Students taught cell biology using Inquiry instructional strategy

		N	Mean	Std. Dev.	df	t-cal	p-value	Remark
NASUT	Male	19	31.53	3.65				
					43	-835	.408	N.S.
	Female	26	32.58	4.50				

*Not Significant at P≤0.05

The p-value of 0.408 obtained as shown in Table 4.3b is greater than the .05 level of confidence. The null hypothesis which states that there is no significant difference in understanding of nature of science and self-efficacy in male and female NCE biology students taught cell biology concepts using inquiry instructional strategy is therefore

retained. This implies that there is no significant difference in the mean scores in understanding of nature of science and self-efficacy between male and female NCE biology students' taught biology concepts using inquiry instructional strategy.

Research Question 4: What is the relationship of self-efficacy and understanding of nature of science among NCE biology students using inquiry instructional strategy?

Questionnaire items 1 to 20 were used to answer research question four for the study. Analysis of data collected to answer the research question is presented in Table 4.4a.

Table 4.4a: Respondents' Opinion on the Relationship between Self-Efficacy and Understanding of Nature of Science of NCE Biology students using Inquiry Instructional Strategy

Option	Total Score	Mean Score	SD	Decision	Remarks
Agreed	619				There is a significant relationship in self-efficacy and understanding of nature of science by NCE I Biology students taught cell biology using inquiry instructional strategy
Disagreed	281	2.89	0.85	2.89>2.5	
Total	900				

The table 4.4a revealed the perception of respondents on the relationship between self-efficacy and understanding of nature of science of NCE biology students using inquiry instructional strategy. The cumulative mean responses of all the items were 2.89 which is greater than the decision mean of 2.50 with the standard deviation value of 0.85 implying that their responses were significant. Specifically, majority were of the opinion that (type Q8) as this item attracted the highest mean response of 3.20 with details showing that 34 respondents were in agreement while the remaining 11 disagreed to this view (see Appendix 7). This implies that there is a relationship between self-efficacy and understanding of nature of science of NCE Biology students using inquiry instructional strategy.

$H0_4$ There is no significant relationship between NCE Biology students understanding of nature of science and their self-efficacy after exposure to inquiry instructional strategy.

Data collected to address the null hypothesis four is presented in table 4.4b.

Table 4.4b: Correlation for Relationship between NCE Biology students understanding of nature of science and their self-efficacy after exposure to inquiry instruction

Variables	N	Mean	Std. Dev.	Df	r-cal	P Value	Remark
Understanding of nature of science	45	3.20	1.05	43	0.910	0.000	Significant
Self-efficacy	45	3.09	0.94				

P≤0.05

The outcome of Table 4.4b revealed a mean score of 3.20 with standard deviation of 1.057 for understanding of nature of science against a mean of 3.09 with standard deviation of 0.949 for self-efficacy. The calculated r value was 0.910 at 0.05 alpha levels of significance. This shows that there is a significant relationship in NCE I Biology students' understanding of nature of science and their self-efficacy after exposure to inquiry instruction as r-cal 0.910 is greater than the p value of 0.05. Hence, the null hypothesis which states there is no significant relationship in NCE Biology students' understanding of nature of science and their self-efficacy after exposure to inquiry instruction is therefore rejected.

4.3 Findings

In this study, the following findings are made:

1. Significant difference exists in the understanding of nature of science of NCE students exposed to structured inquiry-based instruction and those exposed to lecture method in biology. The observed difference is in favour of the experimental group (i.e. those exposed to structured inquiry-based instruction).

2. There is significant difference in the mean scores in self-efficacy between NCE biology students' taught biology concepts using inquiry instructional strategy and those taught using lecture method. The difference is in favour of the males and females in the experimental group.
3. There is no significant difference in self-efficacy and understanding of nature of science between male and female NCE biology students taught biology concepts using inquiry instructional strategy. As indicated by the mean scores, neither the males nor the females significantly exhibit higher level of self-efficacy than the other.
4. There is significant relationship between NCE Biology students understanding of nature of science and their self-efficacy after exposure to inquiry instruction. (i.e. the experimental group). As indicated by the calculated r value which was 0.910 at 0.05 alpha level of significance, in table 4.4b, this shows that there is a significant relationship between NCE Biology students' understanding of nature of science and their self-efficacy after exposure to inquiry instruction.. This finding answered the stated research question number four.

4.4 Discussion of the Results

The result from Table 4.1b shows that there was a significant difference in the mean scores of understanding of nature of science of NCE 1 students exposed to structured inquiry-based instruction (i.e. experimental) and those exposed to lecture method (control group). The difference is in favour of the experimental group. The significant difference found between the two groups was likely due to the use of structured inquiry-based instruction on the experimental group. If the treatment administered has no impact, the two groups are expected to perform equally the same. Since the experimental group performed significantly better, it implies that using

structured inquiry-based instruction in teaching NCE biology students improves their understanding of nature of science.

The finding of this study is in line with that of Staver (2008) who conducted a research on K-10 students using structured inquiry instructional strategy and revealed that structured inquiry instruction promote students' academic understanding and improve science process skills in K-10 students. This also agrees with the findings of Colburn (2011), Furtak (2006), and Palmer's (2006) who found that students exposed to inquiry instruction understand scientific processes better than those taught with lecture method and are able to create laws and critic the existing knowledge as scientific findings are not permanent but subjected to new evidence. The study contradicts that of Shittu (2012) and Idris (2012) who found no significant difference in the mean scores of students exposed to inquiry in the experimental and control group in inquiry instructional applications and creativities using scientific processes.

Result from this study as presented in Table 4.2b indicated that there was a significant difference in the mean scores of self-efficacy of experimental and control group of NCE students. The results showed that experimental group performed significantly better than the control group, meaning that experimental group showed a high sense of self-efficacy in understanding of nature of science than the control group.

The finding of this study is in line with that of Heather (2013) who conducted an investigation in inquiry-based instruction on student's self-efficacy and academic achievement. He asserted that, there is a significant difference between the levels of self-efficacy of students exposed to traditional method. He stressed that students exposed to inquiry-based instruction exhibit high level of self-efficacy in computations, analysis and interpretation of data than those exposed to the traditional method (lecture method). Also in a research conducted by Southerland et al (2006), using inquiry-based instruction to

explore influences on teachers view of nature of science and self-efficacy, they explored affective influences, self-efficacy, learning dispositions, epistemological beliefs and concepts of science. They found that although the teachers improved in their views of NOS and self-efficacy, their inquiry-based instruction influenced the usefulness they felt for the new ideas they were learning.

A result from this study as presented in Table 4.3b shows that, there is no significant difference in the mean scores of males and females in nature of science self-efficacy test exposed to structured inquiry-based instruction (experimental group). This agrees with the findings of Heather (2013) who revealed that there was no significant difference in the efficacy level between the male and female students exposed to inquiry-based instruction during and after the treatment. Kiran and Sungar (2012) in their research work established that no gender difference was found concerning science self-efficacy. This also agrees with the finding of Ravikumar and Manimozhi (2012) who worked with the students of biological sciences at Cuddalore district of Tamil Nadu, India. They reported that the self-efficacy in equipmentation of boys and girls is almost equal among the biology students of Cuddalore. In the same line is also a research work of Louis and Mistele (2012) they reported that when controlled for self-efficacy, females hold lower self-efficacy in mathematics than males and in science there was no difference between females and males in terms of self-efficacy.

The finding disagrees with the research work of Cavallo et al (2001) who found significant gender difference in students' science self-efficacy. They reported that male students began the course with significantly higher self-efficacy and ended the course also with higher self-efficacy than their female counterparts. The result is also in contradiction with Britner (2002) who reported that boys tend to be more efficacious than girls do during the middle school year. Abdullahi (2014) reported in his research work on effects

of guided inquiry teaching method on self-efficacy and academic achievement of NCE Integrated Science students in North-West, Nigeria that there exist a significant difference in the level of self-efficacy of males and females NCE students exposed that males performed better than their female counterparts, meaning that males have high sense of efficacy than the females.

From Table 4.4b there is a significant relationship between NCE Biology students' understanding of nature of science and their self-efficacy after exposure to inquiry instruction This finding is in line with that of Khishfe and Abd-El-Khalick (2002) who reported that there was no difference in how males and females engage in scientific methods and processes. Usman (2000) reported that there was no gender difference in the academic achievement or understanding of science of students when exposed to activity-based methods of instruction such as discovery, problem-solving, inquiry among others. Freedman (2002), David and Stanley (2002), Sungur and Tekkaya (2003), Afuwape and Oludipe (2008) also reported that there are no longer distinguishing difference in the cognitive, affective and psychomotor skill of students in respect of gender when exposed to activity-based tasks.

However, the results contradict those of Njoko (2003) and Nwoju (2006) who observed that male students perform significantly better than female students in integrated science when exposed to activity based-work. Eriba and Sesugh (2006) have also reported that boys out performed girls in science and mathematics.

The result of the present study also showed variability with other researchers who reported differently. For instance, Lee and Burkam (1996) who have reported that females benefited much than boys did from laboratory experiences. Another studies such as Alkhateeb (2001), Bluer and Waltz (2002), Omoniyi (2006) established that males have becoming the advantaged gender in schools, and that fewer males are interested in science

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The study investigated the impacts of inquiry based instruction on self-efficacy and understanding of nature of science among NCE biology students. In line with this, this chapter summarizes the entire study as presented in the following sub-headings:

5.2 Summary

5.3 Summary of major findings

5.4 Implications

5.5 Conclusions

5.6 Contribution to knowledge

5.7 Recommendations

5.8 Limitations of the study

5.9 Suggestions for further studies

5.2 Summary

This study investigated the impact of structured inquiry-based instruction on NCE biology students' self-efficacy and understanding of nature of science in kwara state. The study also tested the impacts of structured inquiry-based instruction on self-efficacy and understanding of nature of science in relation to gender among NCE students. Available literatures relevant to the study were reviewed. Most of these literatures concluded that high level of self-efficacy and understanding of nature of science can be enhanced using effective instructional strategies which recognized active participation of students.

The design of the study was quasi experimental in nature. It was pre-tested, post-tested control and experimental group design. The population of the study comprised all the 2015 NCE 1 biology students (1475 males and 1647 females) of the three NCE

awarding college in kwara state. These colleges were used because they represent the type of colleges found in the state. Two colleges were sampled out using table of randomization. The sampled schools are co-educational and assigned experimental and control group using table of randomization and students from these colleges were identified and randomly selected as sample population.

Ninety (90) NCE 1 students participated in the study as sampled population for both experimental and control group. The data was collected using two instruments namely: Nature of Science Understanding Test (NOSUT) and Nature of Science Self-efficacy Questionnaire (NOSSEQ). The Nature of Science Understanding Test (NOSUT) comprised 40 items with true/false option on nature of science concepts with reliability coefficient of 0.78 while the Nature of Science Self-efficacy Questionnaire (NOSSEQ) was used on NCE 1 biology students to test for change in Self-efficacy level after taught with structured inquiry-based instruction with reliability coefficient of 0.82. The Nature of Science Self-Efficacy Questionnaire (NOSSEQ) consists of 20 items constructed based on likert 4-1scale of Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD) respectively.

The treatment lasted for three weeks consisting of three periods of 60 minutes each. The subjects were taught the cell biology concepts comprising of cell, types of cells, and physical processes of cell such as osmosis and diffusion using structured inquiry-based instruction adapted from Hearther, (2003) and Abd-El Khalick (2007). And the control groups were taught same cell biology concepts using lecture method. At the end of the treatment, study subjects were post-tested. The data collected through the use of NOSUT and NOSSEQ were subjected to descriptive statistics using t-test and Pearson product moment correlation PPMC statistics to determine the significant differences in the self-efficacy and understanding of nature of science of the experimental group. The

result indicated that the level of self-efficacy of NCE 1 biology students taught cell biology concepts using structured inquiry-based instruction was significantly better. Student's gender had no significant effect in their self-efficacy in cell biology concepts when structured inquiry-based instruction is used. From the results, hypotheses one, two and four of the study were rejected, while hypothesis three was retained.

5.3 Conclusion

From the findings of this study the following conclusions are drawn:

1. Structured inquiry-based instruction can be used to improve the self-efficacy level of students in cell biology and other biology concepts which can be taught using practical activities.
2. Structured inquiry-based instruction increases the understanding of nature of science as students are able to evaluate, criticize and interpret data on their own without believing on raw information given to them and this implies that the method can be used to enhance the performance of the learners in cell biology and in other study area of biology.
3. Structured inquiry-based instruction can be used to teach both male and female students because it encaged both gender during the course of study so since it is not gender bias it can enhance students' self-efficacy and understanding of nature of science in biology at NCE level.

5.4 Contribution to Knowledge

The results and findings from this study have made the following contributions to knowledge:

1. Through the study, an instrument was developed which could help in the research work of this kind

2. A lesson plan was also developed during the course of this research work which may be a guide in teaching field.
3. The study was also able to provide a more concise model that if use can enhance learning of science concepts from different fields of studies.

5.5 Recommendations

On the basis of findings emanating from this study, the following recommendations are made:

1. The teaching of Biology especially cell biology should be conducted in such a way that students learn meaningfully and develop true understanding of nature of science so as to be the constructor of the knowledge acquired. The use of structured inquiry-based instruction seems to be appropriate in that respect. It should therefore be incorporated into the main stream of pedagogy in the teaching of biology at NCE level of colleges of education.
2. As structured inquiry-based instruction is very effective in enhancing self-efficacy, and understanding of nature of science of NCE students. State colleges of Education lecturers should employ structured inquiry-based instruction in teaching cell biology concepts so as to improve students' cell biology self-efficacy and understanding of nature of science in cell biology.
3. The use of lecture method of teaching has been found to be less effective in this study with respect to self-efficacy and understanding of nature of science of NCE students. Science teachers should therefore exercise and caution in the use of lecture method to avoid a situation where low self-efficacy and lack of understanding of nature of science is promoted among NCE students.
4. There is the need for college authorities to intensify effort for training and retraining of biology teachers on how to effectively design and use structured

inquiry-based instruction for improved learning and understanding of nature of science skills especially in the light of resources available to the teacher.

5. In service training for science teachers in form of seminars, workshops, conferences should focus more on how to use structured inquiry-based method for the teaching of cell biology concepts. The government or relevant professional bodies like Science Teachers' Association of Nigeria (STAN) could do this.
6. There should be proper provisions of facilities/equipments, which are necessary for effective structured inquiry method.
7. Teachers have problem of developing structured inquiry-based activities therefore manual should be develop by the curriculum planners to serve as guide to assist teachers engage students in structured inquiry-based instruction in the classroom.
8. This study showed that gender does not play a significant role in the learning of cell biology concepts using structured inquiry. Hence, the method is recommended as it is gender friendly and aided learning and understanding between male and female.

5.6 Limitations of the Study

This study has the following limitations:

1. The study was restricted to only the two colleges of education in the kwara state, Nigeria thus it cannot be generalized to other colleges of education with similar facilities.
2. A sample size of only ninety (90) NCE students was used in this study. It may be possible that when larger sample size is used the result may not be the same.

5.7 Suggestions for Further Studies

The following suggestions are made for further studies:

1. Similar studies should be conducted in basic sciences to investigate the impact of structured inquiry-based instruction on self-efficacy and understanding of nature of science at lower educational level. This is to see whether there will be improvement on self-efficacy and understanding of nature of science of the subjects.
2. This study can be extended to undergraduate students to investigate the impact of these variables that this study dealt with.
3. There is the need to conduct similar studies to investigate the impacts of other activity oriented teaching methods such as problem-solving method, project method, discussion method e.t.c. in teaching the concepts of cell biology to NCE students.
4. In order to increase the scope of generalization, this study should be replicated in many other states of Nigeria and many other countries in the world.
5. Other difficult areas of biology or any other science subjects should be investigated using the same approach.

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APPENDIX I

LESSON NOTE FOR THE EXPERIMENTAL GROUP

WEEK 1

Date:
Institution: Kwara State College of Education (T) Lafigai
Mode of Teaching: Structured Inquiry Instructional Strategy
Group: Experimental
Class Level: NCE 1
Age Range: 19 – 22 years
Course: BIO 112
Topic: Cell
Time: 9 – 10am
Duration: 1 hour
Number of Students in Class: 45
Sex: Mixed
Instructional Materials: Microscope, Permanent Slide, Charts Picture, Drawing Paper, Pencil and Pen
Behavioural Objectives: By the end of the lesson, students should be able to

i. Define Cell
ii. Mention Types of Cell
iii. List the characteristic features of cells
iv. Distinguish between the two types of cell

Previous Knowledge: Students have learnt levels of organizations in living organisms

Introduction: The teacher will ask the students the following questions

i. What are the levels of organizations in living organisms
ii. State one example of each

Presentation:

Phase 1: **Task phase:** How to identify cell

Phase 2: **Engagement phase**: The teacher ask the students to write down the name of the materials provided on the tables and also to mention their functions

Phase 3: **Understanding phase**: Here the students try to look and think critically of what they are about doing by carefully studying the materials and the procedure manual given to them

Phase 4: **Experimentation phase:** Here the students begins to embark on their investigations using the procedure manual given to them as follows

i. There are slide A and B, pick slide A and mount it on microscope labeled A and pick slide B and mount it on the microscope labeled B
ii. Carefully observe the two slides
iii. Draw the structures on the slides
iv. Describe the two structures and state their differences in respect to shape and size

Phase 5: **Explanation phase:** The students explain their findings as

i. The two slides viewed under the microscopes are different in terms of structure
ii. The structure in slide A is rectangular while the structure in slide B is spherical

Phase 6: **Inference:** The students give inference base on their findings as

i. Slide A is rectangular and larger than slide B, this shows that slide A contain plant cell
ii. Slide B is spherical in shape and smaller this shows that slide B contain animal cell

Phase 7: **Communication:** The students communicate their findings to the teacher through their note books

Reading Material: The teacher provides the students with a short write up that may guide them during their inquiry work as follow

What is a Cell: Is the smallest unit of living organisms that is capable of performing life functions. All living things including plants and animals are made up of cells.

Types of Cell: There are two major types of cells which are plant cells and animal cells

Differences between Plant Cells and Animal Cells: there are four major differences between them as show in the table below

	Animal Cells	**Plant Cells**
1	Relatively smaller in size	Relatively larger in size
2	Round shape	Relatively rectangular in shape
3	No cell wall	Cell wall present
4	Small vacuole	Large vacuole

Similarities between plant cells and animal cells include the followings; both have a cell membrane, both have nucleus, cytoplasm, vacuole, mitochondnon etc.

Diagram of the plant cell and animal cell is shown below

What are the characteristic features of cell: the characteristics features include:

i. **Cell Membrane:** both plants and animals cell has cell membrane which is made to support, protect and controls movement of materials in/out of cell.
ii. **Nucleus:** both plants and animal cells has it, it controls cell activities.
iii. **Cytoplasm:** Both plant and animal cells has it, it is a clear, thick, jellylike material and organelles found inside cell membrane. It supports/protects cell organelles.

iv. **Mitochondrion:** Both plants and animals cells has it, it is bean – shaped. It breaks down sugar molecules into energy (it is the power house of the cell).

v. **Vacuole:** Both plant and animal cell has it but larger in plant and very small in animals. It is a fluid filled sac. It store food, water and waste.

vi. **Chloroplast:** It is only present in plant cell and not in animal cell. It is green, oval usually containing chlorophyll. It uses energy from sun to make food for the plant.

vii. **Cell Wall:** it is only present in plant and absent in animal cells. It is the outer most layers, rigid, strong, stiff made of cellulose in plants. It is for support protection and allowing water, oxygen, carbon (iv) oxide to pass into and out of cell.

Evaluation: The teacher evaluates the lesson by asking the students the following

questions.

i. What is a Cell
ii. What are the Types of Cell
iii. What are the Differences between the Two Types of Cell

Assignment: The teachers give assignment as

i. Mention five different cells in human body and state their function each?

WEEK 2 LESSON NOTE FOR THE EXPERIMENTAL GROUP

Date:

Institution: Kwara State College of Education (Technical) Lafigai

Mode of Teaching: Structured Inquiry Instructional Strategy

Group: Experimental

Class Level: NCE 1

Age Range: 19 – 22 years

Course: BIO 112

Topic: Diffusion in Plants

Time: 9 – 10am

Duration: 1 hour

Number of Students in Class: 45

Sex: Mixed

Instructional Materials: College Garden, Paper, and Pen

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

i. Define Diffusion
ii. List factors affecting diffusion
iii. Explain how diffusion take place in a living plant

Previous Knowledge: Students have been taught cell and it structural functions

Introduction: The teacher will ask the students the following questions:

i. What is a Cell
ii. What are the Types of Cell
iii. What are the difference between the two Types of Cell

Presentation:

Phase 1: **Task phase:** The teacher introduces the students to the task as "to demonstrate diffusion in a plant"

Phase 2: **Engagement phase**: The teacher ask the students to move to the school garden with note books and pen

Phase 3: **Understanding phase:** The students try to reason, for what kind of the activity they are going to do in the garden and try to read through the practical manual given to them by the teacher

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Phase 4: **Experimentation phase:** The teacher ask the students to carefully observe the plants in the garden and record whatever they observed

Phase 5: **Explanation phase:** The students explain their observations as;

i. There are many plants in the garden; some are short while some are tall.

ii. These plants contain water suspended on their leaves

iii. The water on their leaves vary; some has little while some has much of water.

Phase 6: **Inference Phase:** The students make their inference base on their observation as follows

i. There was water movement from the internal environment of cell to the outside environment.

ii. The pores where the water vapour passes to the outside environment vary in number.

iii. Because, there was much water inside the cell, that is why the cell has to remove excess water through diffusion inform of transpiration.

Phase 7: **Communication phase:** The students communicate their findings to the teacher through their note books

Reading Material: The teacher provides the students with a short write up so as to guide them during their investigations as follows.

What is Diffusion?: Is a thermal process by which molecules of substances move randomly from a region of high concentration to a region of low concentration until the molecules of the substance are evenly distributed between the regions where do diffusion occur? It occurs in both living and non living media; as it is the main process by which substances move from one place to the other in the body of living things.

Examples of Diffusion in Plants:

i. Gaseous exchange in many unicellular animals.

ii. Absorption of the end products of digestion.

What are the Factors Affecting Diffusion?: These factors includes

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i. **State of Matter:** Diffusion depends on whether the substance involve is in a gaseous, liquid or solid state.

ii. **Molecular Size:** The smaller the molecular size, the faster will be the rate of diffusion.

iii. **Concentration Gradient:** This is the relative difference in the concentration of the substance between the two regions before the process of diffusion takes place.

iv. **Temperature:** The higher the temperature, the higher the rate of diffusion.

Evaluation: The teacher evaluates the lesson by asking the students the following questions

i. What is Diffusion?

ii. What is the Factors Affecting Diffusion?

iii. How did diffusion occur in Plant Cells?

WEEK 3 LESSON NOTE FOR THE EXPERIMENTAL GROUP

Date:

Institution: Kwara State College of Education (Technical), Lafigai

Mode of Teaching: Structured Inquiry Instructional Strategy

Group: Experimental

Class Level: NCE 1

Age Range: 19 – 22 years

Course: BIO 112

Topic: Osmosis in Potato

Time: 9 – 10am

Duration: 1 hour

Number of Students in Class: 45

Sex: Mixed

Instructional Materials: 3 Bowls, Water, Salt, Sugar, Potato, Knife, Paper, Pencil or Pen

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

i. Define Osmosis
ii. Explain concentration gradient
iii. Explain semi permeable membrane
iv. Explain or demonstrate how osmosis takes place in potato

Previous Knowledge: Students have been taught diffusion in a living cell.

Introduction: The teacher will ask students the following questions:

i. What is Diffusion?
ii. What are the factors affecting diffusion?

Presentation:

Phase 1: **Task phase:** The teacher introduces the task to the students as "to demonstrate osmosis in potato"

Phase 2: **Engagement phase:** The teacher will give the materials to be use to the students and ask them to mention the uses of each item provided to them on their papers.

Phase 3: **Understanding phase:** The students list the items given to them and start to think for their possible usage. 113

Phase 4: **Experimentation phase:** The students start to embark on their investigation using the procedural manual given to them by the teacher as follows.

i. Fill each of the bowls about half full of water
ii. Place the bowls on a table where they can sit for several hours without being in the way
iii. Use the paper and pen to make a label for each bowl. The label can be A, B, and C, or as plain water, salt and sugar respectively.
iv. Add 2 spoon of salt to the water bowl labeled "salt" and keep stirring for about 2 minutes.
v. Do the same as in (iv) above for bowl labeled sugar using sugar.

vi. Carefully use the knife to cut three slices from the potato, each slice should be about ¼ or ½ of an inch thick.

vii. Place one slice in each bowl and leave the experiment for 30 minutes.

viii. After 30 minutes, take the potato out of the bowl labeled "salt" and examine it, what do you see?, do the same for bowl labeled sugar.

ix. Rinse your fingers to get rid of any salt or sugar and pick up the slice in the plain water (what do you notice about it).

Phase 5: **Explanation phase:** The students explain their observations as;

i. In the bowl labeled salt, the slice of potato in it becomes wilted and flexible.

ii. In the bowl labeled sugar, the slice of potato in it, becomes wilted and flexible but not as wilted and flexible as that of slice in salt.

iii. In the bowl labeled as plain water, the slice of potato in it is not wilted at all but become more rigid than it initial texture.

Phase 6: **Inference Phase:** The students make their inference base on their investigation as

i. There was water movement from the cells of the potato into the salt environment.

ii. There is water movement from the cells of the potato into the sugar environment.

iii. There water movement from the plain water into the cells of the potato. 114

iv. From the above observation osmosis has taken place between the various solutions and the slice of potatoes in them. Invariably, water move from a region of low concentration of solute to high concentration of solute.

Phase 7: **Communication phase**: The students communicate their findings to the teacher through their note books.

Reading Material: The teacher provides the students with a short write up that may guide them during their investigations as follows.

What is Osmosis?: Is a random movement of water molecules from an area of high concentration to an area of lower concentration through semi permeable membrane.

What is Semi Permeable Membrane: It means a membrane that allows passage of only certain types of molecules by diffusion. All plants and animals cell have membrane.

What is Concentration Gradient: Is the relative difference in the concentration of the substance between the two regions before the process of diffusion takes place.

What are the conditions necessary for osmosis to take place? They include:

i. What is Osmosis?

ii. What are the Factors Affecting Osmosis?

iii. What is Semi Permeable Membrane?

iv. Explain what happen to a cell put inside a salt solution.

Assignment: The teachers ask the students to demonstrate osmosis in an animal?

APPENDIX II

LESSON NOTE FOR THE CONTROL GROUP

WEEK 1

Date:
Institution: Kwara State College of Education Ilorin
Mode of Teaching: Lecture Method Instructional Strategy
Group: Control Group
Class Level: NCE 1
Age Range: 19 – 22 years
Course: BIO 112
Topic: Cell
Time: 2 – 3pm
Duration: 1 hour
Number of Students in Class: 45
Sex: Mixed
Instructional Materials: Chart and Diagrams
Specific Objectives: The teacher should

i. Define Cell
ii. Describe Cell
iii. Mention Types of Cell
iv. List the Characteristic Features of Cell
v. Differentiate between Plant and Animal Cell

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

i. Define Cell
ii. Mention Types of Cell
iii. Differentiate between Plant and Animal Cell.

Previous Knowledge: Students have been taught levels of organization in living things.
Introduction: The teacher will ask the students the following questions:

i. How many levels of organization do we have in living things?

Presentation:

Step 1: The teacher define cell to the students

Step 2: The teacher describe cell to the students

Step 3: The teacher mention the types of cells to the students

Step 4: The teacher explains the differences and similarities in the two types of cell mentioned.

Step 5: The teacher lead the students to observe the chart and diagram to see the types of cell.

Evaluation: The teacher will evaluates the lesson by asking the students the following questions.

i. What is a Cell?
ii. Mention the two Types of Cells
iii. What is the main structural difference between the two type of cells mentioned?
iv. What are the similarities between the two types of Cells?

Assignment: The teacher will give the following assignment.

i. Make a well label diagram of plant and animal cell.
ii. Draw the followings a – red blood cell and b – bone cell.

Board Summary: The section incorporates the main points, which emerge from the lesson.

- Cell is the basic, structural and functional unit of life
- The two main types of cells are plant cell and animal cell
- Plant cell is rectangular in shape while animal cell is spherical in shape.
- Plant cells have cell wall, chloroplast and large vacuole while animal cell has no cell wall, chloroplast but has small vacuole.
- Both plant cells and animal cells has the followings in common; mitochondrion, nucleus, cytoplasm, endoplasmic reticulum, Golgi bodies.

WEEK 2 LESSON NOTE FOR THE CONTROL GROUP

Date:
Institution: Kwara State College of Education Ilorin
Mode of Teaching: Lecture Method Instructional Strategy
Group: Control Group
Class Level: NCE 1
Age Range: 19 – 22 years
Course: BIO 112
Topic: Diffusion in Plants
Time: 2 – 3pm
Duration: 1 hour
Number of Students in Class: 45
Sex: Mixed
Instructional Materials: Chart and Diagrams
Specific Objectives: The teacher should

i. Define Diffusion
ii. Explain how diffusion takes place in plant
iii. List and explain factors affecting diffusion

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

i. Define Diffusion
ii. Explain how diffusion takes place in a plant
iii. Mention factors affecting diffusion

Previous Knowledge: Students have been taught cell
Introduction: The teacher will ask the students the following questions:

i. What is a Cell?
ii. What are the Types of Cell?
iii. What are the differences between plant cell and animal cell?

Presentation:
Step 1: The teacher define diffusion to the students
Step 2: The teacher explain how diffusion takes place in plant.
Step 3: The teacher explain the factors affecting diffusion
Step 4: The teacher mention some examples of diffusion in plants and animals.
Evaluation: The teacher evaluates the lesson by asking the students the following questions.

i. What is Diffusion?
ii. What are the factors affecting diffusion?
iii. Explain diffusion in a plant?

Assignment: The teachers give the following question to the student as

i. Explain diffusion processes in non – living things.

Board Summary: The teachers highlight some main points from the lesson to the students as.

- Diffusion is a process by which molecules of substances move randomly from a region of high concentration to a region of

low concentration until the molecules of the substance are evenly distributed between the two regions.

- Diffusion occurs in both plants and animals and non – living things
- Examples of diffusion in living things are
  i. The movement of oxygen from the atmosphere into the leaves via the stomata
  ii. The movement of water vapour out of the cells (transpiration)
  iii. Gaseous exchange in many unicellular animals e.g. Amoeba
  iv. Absorption of the end products of digestion
- Factors affecting diffusion includes
  i. State of matter
  ii. Molecular size
  iii. Concentration gradient and
  iv. Temperature

WEEK 3 LESSON NOTE FOR THE CONTROL GROUP

Date:
Institution: Kwara State College of Education Ilorin
Mode of Teaching: Lecture Method Instructional Strategy
Group: Control Group
Class Level: NCE 1
Age Range: 19 – 22 years
Course: BIO 112
Topic: Osmosis in Potato
Time: 2 – 3pm
Duration: 1 hour
Number of Students in Class: 45
Sex: Mixed
Instructional Materials: Chart and Diagrams
Specific Objectives: The teacher should

i. Define Osmosis
ii. Explain how molecules of water move into and out of cell
iii. Explain semi permeable membrane in cell, concentration gradient.
iv. Explain how Osmosis take place in potato

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

i. Define Osmosis
ii. Explain how molecules move into and out of cells
iii. Explain what semi permeable membrane and concentration gradient
iv. Explain how Osmosis takes place in potato

Previous Knowledge: Students have been taught diffusion and it processes
Introduction: The teacher will ask the students the following questions:

i. What is Diffusion?
ii. What are the factors affecting diffusion?

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Presentation:
Step 1: The teacher define Osmosis
Step 2: The teachers explain how molecules into and out of cell.
Step 3: The teacher explain semi permeable membrane and concentration gradient.
Step 4: The teacher explain how Osmosis take place in a slice potato.
Evaluation: The teacher evaluates the lesson by asking the students the following questions.

i. What is Osmosis?
ii. What is semi permeable membrane
iii. What is concentration gradient
iv. What happens when a slice of potato is put in a salt solution and other in a sugar solution after 30 minutes?

Assignment: State the differences between Osmosis and diffusion?

Board Summary: The teachers incorporate the main points which emerge from the lesson.

- Osmosis: Is a random movement of water molecules from an area of high concentration to an area of lower concentration through semi permeable membrane.
- A semi permeable membrane is a membrane that allows passage of only certain types of molecules by diffusion.
- Concentration gradient: is the relative difference in the concentration of the substance between the two regions before the process of diffusion takes place.
- Osmosis takes place in both plant and animals
- Example of Osmosis in plants and criminals include:
  i. Absorption of water from the soil by the root
  ii. The entry of water into the cytoplasm of unicellular animals
  iii. Movement of water in and out of living plant cells.
- Osmosis in a slice of potato involves the followings
  i. There are 3 bowls ½ filled with water
  ii. The first bowl is label A and 2 tea spoon of salt put into it and stir, the second bowl is labeled B and 2 teaspoons of sugar are pour into it and stir also while the last bowl labeled C is left as a plain water.
  iii. The potato is sliced into 3 pieces and put into each bowl A, B, and C.
  iv. After 30 minutes, the 3 slices are removed and observed.
  v. From the observation, bowl A slice potato become wilted and flexible, bowl B slice potato becomes wilted a flexible but not as bowl A potato while bowl C slide potato even become rigid and hard.
  vi. From the above observation, it shows that Osmosis has taken place in the three bowls.
  - Osmosis terms which include
  i. Hpertonic: a stronger solution
  ii. Hypotonic: a weaker solution
  iii. Isotonic: a moderate or evenly distributed solution.

APPENDIX III

REQUEST FOR VALIDATING A RESEACH INSTRUMENT

Science Education Department, ABU, Zaria

To: PROF. J.S MARI

VALIDATING A RESEARCH INSTRUMENT

I have adapted a research instrument design to generate data for my M.Sc (Ed) Thesis on Understanding of Nature of Science and Nature of Science Self-Efficacy Questionnaire in Kwara State Colleges of Education.

The instrument titled, Nature of Science Understanding Test (NOSUT) consist of 40 statement items drawn from the characteristics of scientist view and opinion. It is to be used as both pre-test and post-test while the Nature of Science Self-Efficacy Questionnaire (NOSSEQ) consit of 20 statement items drawn.

As an experience science education lecturer, assessment of these items from you would certainly improve the quality and standard of the instrument. I would like you to please examine the items with respect to the following:

I. Do the items really related to the understanding of nature of science expected of NCE students?
II. Are the items readable, standard and free from ambiguity?
III. What general criticism and suggestions can you give for the improvement of the instrument?

I will be very much grateful and appreciate your assistance please.

Yours Sincerely,

Dangana Musa.

P13EDSC8038

REQUEST FOR VALIDATING A RESEACH INSTRUMENT

Science Education Department, ABU, Zaria

To: PROF. A. ISSA

VALIDATING A RESEARCH INSTRUMENT

I have adapted a research instrument design to generate data for my M.Sc (Ed) Thesis on Understanding of Nature of Science and Nature of Science Self-Efficacy Questionnaire in Kwara State Colleges of Education.

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I will be very much grateful and appreciate your assistance please.

Yours Sincerely,

Dangana Musa.

124 P13EDSC8038

REQUEST FOR VALIDATING A RESEACH INSTRUMENT

Science Education Department, ABU, Zaria

To: DR. S.S BICHI

VALIDATING A RESEARCH INSTRUMENT

I have adapted a research instrument design to generate data for my M.Sc (Ed) Thesis on Understanding of Nature of Science and Nature of Science Self-Efficacy Questionnaire in Kwara State Colleges of Education.

The instrument titled, Nature of Science Understanding Test (NOSUT) consist of 40 statement items drawn from the characteristics of scientist view and opinion. It is to be used as both pre-test and post-test while the Nature of Science Self-Efficacy Questionnaire (NOSSEQ) consit of 20 statement items drawn.

As an experience science education lecturer, assessment of these items from you would certainly improve the quality and standard of the instrument. I would like you to please examine the items with respect to the following:

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III. What general criticism and suggestions can you give for the improvement of the instrument?

I will be very much grateful and appreciate your assistance please.

Yours Sincerely,

Dangana Musa.

P13EDSC8038

APPENDIX IV

THE NATURE OF SCIENCE UNDERSTANDING TEST INSTRUMENT (NOSUT)

MATRIC NO:_____

SEX:_____

COURSE COMBINATION:_____

Please choose whether it is true or false with each of the following statements about the nature of science by ticking ( ) the response of your choice.

1. The most important scientific ideas have been the result of a systematic process of logical thought. **True( ) False( )**
2. Classification schemes are not imposed upon nature, by the scientists: they are not inherent in the materials classified. **True( ) False( )**
3. Thanks to the discovery of the scientific method, new discoveries in science have begun to come faster. **True( ) False( )**
4. The primary objective of the working scientist is to improve human welfare. **True( ) False( )**
5. While a scientific hypothesis may have to be altered on the basis of newly discovered data, a physical law is not permanent**. True( ) False( )**
6. The scientific investigation of human behavior is useless because it is subject to unconscious bias of the investigator. **True( ) False( )**
7. Science is constantly working toward previous details and simple knowledge **True( ) False( )**
8. A fundamental principle of science is that discoveries and research should not have some practical applications**. True( ) False( )**
9. While biologists use the deductive approach to a problem, other scientists also work deductively. **True( ) False( )**
10. The ultimate goal of all science is to reduce observations and phenomena to a collection of mathematical relationships **True( ) False( )**
11. The best definition of science would be “an organized body of knowledge **True( ) False( )** **126**
12. Science tries mainly to develop new machines and processes for the betterment of mankind. **True( ) False( )**

13. Any scientific research broader than a single specialty can only be carried out through the use of a team of researchers from various relevant fields **True( ) False( )**

14. Investigation of the possibilities of creating life in the laboratory is an invasion of science into area where it does not belong**. True( ) False( )**

15. Team research is more productive than individual research. **True( ) False( )**

16. Many scientific models are man-made and do not pretend to represent reality **True( ) False( )**

17. Scientific investigation follow definite approved procedures **True( ) False( )**

18. Most scientists are not reluctant to share their findings with foreigners, being mindful of the problem of national security. **True( ) False( )**

19. The essential test of a scientific theory is its ability to correctly predict future events **True( ) False( )**

20. When a large number of observations have shown results consistent with a general rule, this generalization is considered to be a universal law of nature. **True( )False( )**

21. The scientific method follows the five regular steps of defining the problem, gathering data, forming a hypothesis, testing it, and drawing conclusions from it. **True( ) False( )**

22. One of the distinguishing traits of science is that it does not recognizes its own limitations **True( ) False( )**

23. The experiment of diffusion through a semi permeable membrane was one of the earliest and most important developments of modern science **True( ) False( )**

24. Scientific research should be given credit for producing such things as modern dialysis machine, separation of attached twins and blood transfusion. **True( ) False( )**

25. If at some future data it is found that solute molecules does not diffuse through a membrane, today's practices in designing osmosis and diffusion apparatus will have to remain**. True( ) False( )**

26. By application of the scientific method, step by step, man can solve almost any problem or answer almost any questions in the realm of nature **True( ) False( )**

27. Scientific method is a myth which is usually read into the story after it has been completed. **True( ) False( )**

28. Scientific work requires a dedication that does not excludes many aspects of the lives of people in other fields of work. **True( ) False( )**

29. An important characteristic of the scientific enterprise is its emphasis on the theoretical. **True( ) False( )**

30. There are many ways to classify nature, but agreeing on one universal system allows scientists to avoid confusion in their work. **True( ) False( )**

31. There could be other correct ways to classify nature, because science is liable to change and new discoveries may lead to different classifications. **True( ) False( )**

32. Nobody knows the way nature really is. Scientists classify nature according to their perceptions or theories. Science is never exact, and nature is so diverse. Thus, scientists could not correctly use more than one classification scheme **True( ) False( )**

33. The scientific method is useful in many instances, but it does not ensure results. Thus, the best scientists will also use originality and creativity**. True( ) False( )**

34. The best scientists are those who use any method that might get favorable results (including the method of imagination and creativity)**. True( ) False( )**

35. . Many scientific discoveries were made by accident, and not by sticking to the scientific method . **True( ) False( )**

36. Errors slow the advance of science. Misleading information can lead to false conclusions. If scientists do not immediately correct the errors in their results, then science is not advancing. **True( ) False( )**

37. Errors slow the advance of science. New technology and equipment reduce errors by improving accuracy and so science will advance slower**. True( ) False( )**

38. Because there is always room for error and unforeseen events that will affect a result. No one can predict the future for certain. **True( ) False( )**

39. Because accurate knowledge changes as new discoveries are made, and therefore predictions will always change. **True( ) False( )**

40. Because a prediction is not a statement of fact. It is an educated guess.

True( ) False( )

APPENDIX V

MARKING SCHEME FOR NATURE OF SCIENCE UNDERSTANDING TEST (NOSUT)

1. True = 1 point
2. False= 1 point
3. True = 1 point
4. True = 1 point
5. False= 1 point
6. True= 1 point
7. False= 1 point
8. False= 1 point
9. False= 1 point
10. True= 1 point
11. True= 1 point
12. True= 1 point
13. True= 1 point
14. False= 1 point
15. True= 1 point
16. False= 1 point
17. True= 1 point
18. False= 1 point
19. True= 1 point
20. True= 1 point
21. True= 1 point
22. False= 1 point
23. True= 1 point
24. True= 1 point
25. False= 1 point
26. True= 1 point
27. False= 1 point
28. False= 1 point
29. False= 1 point
30. True= 1 point
31. True= 1 point
32. False= 1 point
33. True= 1 point
34. True= 1 point
35. False= 1 point
36. True= 1 point
37. False= 1 point
38. True = 1 point
39. True = 1 point
40. True = 1 point

The total marks for the 40 items is 40

APPENDIX VI

NATURE OF SCIENCE SELF-EFFICACY QUESTIONNAIRE (NOSSEQ)

Registration Number:_____

Sex:_____

As a future science teacher, please indicate the degree to which you agree with each statement below using the following indicators:

SA=STRONGLY AGREE, A=AGREE, D=DISAGREE, OR SD=STRONGLY DISAGREE

S/N	QUESTION	SA	A	D	SD
1	When I do better than usual in biology, it is because I understand nature of science.				
2	There are many ways to classify nature, but agreeing on one universal system allows scientists to avoid confusion in their work.				
4	Increase effort in learning biology produces little change in students' understanding of nature of science achievement.				
5	The method the learner use in learning, is generally responsible for the understanding of the learner in biology.				
6	Because accurate knowledge changes as new discoveries are made, and therefore predictions will always change.				
7	If your parents comment that you are showing more interest in activity-based learning, it is probably due to your new learning instruction				
8	There could be other correct ways to classify nature, because science is liable to change and new discoveries may lead to different classifications.				
9	Errors slow the advance of science. New technology and equipment reduce errors by improving accuracy and so science will advance faster.				
10	One of the distinguishing traits of science is that it recognizes its own limitations.				
11	Scientific method is a myth which is usually read into the story after it has been completed.				
12	An important characteristic of the scientific enterprise is its emphasis on the practical.				
13	The essential test of a scientific theory is its ability to correctly predict future events				
14	If at some future data it is found that blood does not consist of cells, today's practices in designing blood sample apparatus will have to be discarded.				
15	Most scientists are reluctant to share their findings with foreigners, being mindful of the problem of national security				

16	Many scientific models are man-made and do not pretend to represent reality				
17	Scientific investigation follow definite approved procedures				
18	The scientific investigation of human behavior is useless because it is subject to unconscious bias of the investigator.				
19	The most important scientific ideas have been the result of a systematic process of logical thought.				
20	While biologists use the deductive approach to a problem, physicists always work inductively.				

APPENDIX VII

NATURE OF SCIENCE SELF-EFFICACY QUESTIONNAIRE (NOSSEQ)

MARKING PATTERN

The following is the way the four point Likert scale will be scored

1. Strongly Agree = 4points
2. Agree = 3points
3. Disagree = 2points
4. Strongly Disagree = 1point

The total marks for the 20 items will be 80

NOSSEQ RESULT THE FOR CONTROL GROUP

Q1. SA=7, A=8, D=18, SD=12 =45

Q2. SA=9, A=6, D=11' SD=19 =45

Q3. SA=6, A=2, D=12, SD=25 =45

Q4. SA=8, A=7, D=10, SD=20 =45

Q5. SA=9, A=5, D=21, SD=10 =45

Q6. SA=4, A=10, D=16, SD=15 =45

Q7. SA=3, A=7, D=18, SD=17 =45

Q8. SA=10, A=4, D=15, SD=16 =45

Q9. SA=12, A=5, D=13, SD=15 =45

Q10. SA=3, A=5, D=25, SD=12 =45

Q11. SA=9, A=7, D=18, SD=11 =45

Q12. SA=3, A=11, D=19, SD=12 =45

Q13. SA=8, A=7, D=12, SD=18 =45

Q14. SA=2, A=5, D=20, SD=18 =45

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Q15. SA=9, A=6, D=11, SD=19 =45

Q16. SA=3, A=10, D=12, SD=20 =45

Q17. SA=10, A=5, D=16, SD=14 =45

Q18. SA=11, A=4, D=18, SD=12 =45

Q19. SA=4, A=7, D=16, SD=18 =45

Q20. SA=6, A=2, D=18, SD=19 =45

RESULT FOR THE EXPERIMENTAL GROUP

Q1. SA=15, A=17, D=6, SD=7 =45

Q2. SA=20, A=13, D=7, SD=5 =45

Q3. SA=15, A=18, D=8, SD=4 =45

Q4. SA=17, A=16, D=10, SD=2 =45

Q5. SA=12, A=15, D=8, SD=10 =45

Q6. SA=18, A=12, D=10, SD=5 =45

Q7. SA=15, A=16, D=4, SD=10 =45

Q8. SA=25, A=9, D=6, SD=5 =45

Q9. SA=12, A=15, D=12, SD=8 =45

Q10. SA=22, A=10, D=5, SD=8 =45

Q11. SA=18, A=13, D=2, SD=12 =45

Q12. SA=12, A=19, D=11, SD=3 =45

Q13. SA=20, A=10, D=6, SD=9 =45

Q14. SA=14, A=15, D=7, SD=9 =45

135

Q15. SA=18, A=17, D=6, SD=4 =45

Q16. SA=15, A=11, D=9, SD=10 =45

Q17. SA=13, A16, D=7, SD=9 =45

Q18. SA=17, A=18, D=3, SD=7 =45

Q19. SA=13, A=15, D=7, SD=10 =45

Q20. SA=15, A=18, D=2, SD=10 =45

APPENDIX VIII

COLLEDATED RESULT ON NATURE OF SCIENCE UNDERSTANDING TEST (NASUT) FOR BOTH EXPERIMENTAL AND CONTROL GROUPS. IT IS A 40 ITEM QUESTIONS WHICH IS SCORED OVER 40 BY 45 STUDENTS

S/N	SEX FOR	EXPTAL	SEX FOR	CONTRL
1	F	38	F	11
2	F	32	F	15
3	F	37	F	19
4	F	30	F	18
5	F	29	F	8
6	F	32	F	10
7	F	36	F	16
8	F	38	F	17
9	F	38	F	12
10	F	25	F	11
11	F	29	F	11
12	F	32	F	10
13	F	31	F	9
14	F	35	F	3
15	F	30	F	5
16	F	35	F	25
17	F	37	F	14
18	F	38	F	15
19	F	26	F	29
20	F	31	F	30
21	F	34	F	20
22	F	35	F	19
23	F	38	F	17
24	F	22	M	18
25	F	27	M	12
26	F	32	M	11
27	M	34	M	10
28	M	34	M	14
29	M	32	M	14
30	M	27	M	21
31	M	29	M	16
32	M	28	M	35
33	M	33	M	26
34	M	36	M	10
35	M	35	M	12
36	M	34	M	14
37	M	35	M	15
38	M	32	M	17
39	M	31	M	29
40	M	23	M	32
41	M	26	M	19

42	M	37	M	13
43	M	31	M	23
44	M	30	M	21
45	M	32	M	23

Appendix IX

Output of Data Analysis

```
NPAR TESTS
  /M-W= tsequestionnaire BY group(1 2)
  /STATISTICS=DESCRIPTIVES
  /MISSING ANALYSIS.
```

NPar Tests

[DataSet0]

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
total self efficacy	90	49.71	9.932	35	69
group	90	1.50	.503	1	2

Mann-Whitney Test

Ranks

	Group	N	Mean Rank	Sum of Ranks
total self efficacy	experimental	45	66.96	3013.00
	Control	45	24.04	1082.00
	Total	90		

Test Statistics[a]

	total self efficacy
Mann-Whitney U	47.000
Wilcoxon W	1082.000
Z	-7.797
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: group

[DataSet2] C:\Users\Dell\Documents\Dangana.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Experimental	32.13	45	4.154	.619
	Control	16.64	45	7.132	1.063

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Experimental & Control	45	-.301	.045

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Experimental - Control	15.489	9.270	1.382	12.704	18.274	11.208	44	.000

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Experimental	52.07	45	15.226	2.270
	Control	27.56	45	16.652	2.482

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Experimental & Control	45	.139	.364

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Experimental - Control	24.511	20.950	3.123	18.217	30.805	7.849	44	.000

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Gender	1.58	45	.499	.074
	Experimental	32.13	45	4.154	.619

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Gender & Experimental	45	.126	.408

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Gender - Experimental	-30.556	4.121	.614	-31.794	-29.318	-49.743	44	.000