AWARENESS AND ATTITUDE OF CHEMISTRY TEACHERS TOWARDS IMPLEMENTATION OF GREEN CHEMISTRY AMONG SECONDARY TEACHERS IN MINNA METROPOLIS

BY

LUKA, Kingsley

2016/3/64480BE

A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF SCIENCE EDUCATION, SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

NIGER STATE

IN PARTIAL FULFILMENT TO THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF TECHNOLOGY (B TECH) DEGREE IN CHEMISTRY EDUCATION

NOVEMBER, 2019

TABLE OF CONTENTS

CHAPTER TWO

LIST OF TABLES

ABSTRACT

Green chemistry focuses on the molecular level to design chemicals and materials to be inherently non-hazardous. The challenge of promoting greater adoption of green chemistry innovations is education is substantial because green chemistry is an emerging disruptive technology embedded in a complex scientific, political, regulatory, economic, industrial and cultural framework. In implementing an effective teaching, teachers should also integrate various teaching strategies which are suitable to the interest, talent and cognitive level of the students. The main purpose of this study was centered on the awareness and attitude of chemistry teachers towards implementation of green chemistry among secondary school teachers in Minna metropolis. A survey research design was adopted for the study. All the 22 public senior secondary school chemistry teachers formed the population a purposeful random simple technique was used to sample of fifty(50) teachers from the school. Four research questions and two research hypotheses tested at 0.05 level of significance guided the study. A structured questionnaire was used for data collection. The reliability coefficient of the instrument was 0.92 using correlational analysis while two experts carried out face and content validations. Means and standard deviation were employed to answer the research questions, while t-test was used to test the hypotheses. It was found out that the teachers have poor awareness of green chemistry and do not carry out green chemistry practices. The data also revealed that the teachers are positive attitude towards green chemistry and that gender has no effect on the awareness and attiude of teachers towards green chemistry. It was recommended that more benign topics (Green Chemistry topics) in senior school chemistry curriculum should be encouraged and that teachers should be retrained on how to use less toxic chemistry and how to effectively carry out green chemistry practices.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

At the dawn of the 21st century, a powerful and complex web of interactions has contributed to unprecedented universal trend in environmental degradation (UNESCO, 2012). These include rapid globalization, urbanization, poverty, unsustainable consumption patterns and population growth. Global climate change, depletion of the ozone layer, desertification, deforestation, loss of the planets biological diversity, production of hazardous wastes and chemicals are all environmental problems that touches every nation and adversely affect the lives and health of their populations (UNEP, 2012). With the ever growing human population in Nigeria, now two hundred and one million (UNFPA 2019), environmental pollution, depletion and persistent power failures, the country needs a different energy source, more environmental friendly products and process that are more reliable, safe, secure and affordable.

Education is the vehicle through which these problems can be addressed. One important point within the National Philosophy of Education is the element of knowledge, as well as the role of the premise within the development of individual and the society (NPE, 2004). As the fundamental concept within the realm of academic, National Philosophy of Education focuses towards the factor of individual within several relation and connection, Nigeria like other nations sees education as a viral instrument for national development. This fact is contained in the National Policy of Education of Nigeria (NPE, 2004) which spelt out broad goals that includes; the acquisition of appropriate skills and the development of metal physical and social abilities and

competencies as equipment for the individual to live in and contribute to the development of the society (NPE, 2004).

Over the years, environmental education has been one of the main interests of schools, organizations, local communities, private sector and local government but there is inadequate plan to establish an environmental education curriculum that unifies effective approach to teaching environmental education. Education is a process that can change the perception of each individual, thus education plays an important role in increasing every individual's awareness in maintaining the environment preservation by integrating environmental sustainability in the curriculum.

Irrespective of the various environmental degradation enacted to protect the environment, environmental degradation has continued. Education has a strategic role in generating environmental sustainability by empowering the younger generation. Even though environmental education has been included in the course work of some subject in secondary schools such as chemistry, the effect is yet to be felt, this is because some of these activities causing pollution are carried out in the school laboratories.

Chemistry is a branch of pure and basic science which deals with the study of nature, composition, properties (physical and chemical) and uses of matter and the changes matter would undergo under the different conditions (IUPAC, 2000). Chemistry as a basic science which act as a manufacturer in fulfilling human needs and thus uses chemicals that causes pollution in all manner of way. Chemistry is a central science subject because every sphere of human life and development depends so much on the advances of chemistry from the food we eat, the water we drink the clothes we wear, shelter, agriculture, transportation to our daily energy needs. The

results of various researches in chemistry have impacted virtually every part of the world today. We live in a world where we cannot do without the use and applications of chemicals in its various forms, chemicals usually have health and safety implications. There is therefore a need to change the way science is being conducted by adopting a cleaner practices and less toxic chemical substances.

Reports have shown a negative attitude of students generally to science such as chemistry, researchers opined that the lack of interest in chemistry subject is majorly as a result of the context of the syllabus (Yusuf & Ali, 2012). Also, secondary school students perceived chemistry syllabus as being too wide and involving too many calculations and chemistry as being too abstract. Most chemistry students from secondary schools are not able to apply principles taught in the classroom or how to relate the theories with the practical everyday living.

Chemistry has improved our quality of life, and made thousands of products possible, unfortunately, this achievement has come at a price, that is, human health and environmental degradation. The land and air are contaminated with a large number of synthetic industrial chemicals many of which are known to be toxic, causes pollution and carcinogenic while others remain untested for other health effects.

In Nigeria, up to 80% of the waste released into the air, water and land everyday comes from the chemical and its supplementary industries. It is high time the country keeps up with the best practices of green chemistry to ensure a better future. Chemicals are produced with the belief that any chemical hazards can somehow be controlled or managed by establishing safe concentrations and exposure limits over the years, the chemistry community and in particular the chemical industry has made extensive efforts to reduce the risks associated with the manufacture and use of

various chemicals (Onuegbu, T.U and Ekemezie P.N,2009). There have been innovative chemistries developed to treat chemical wastes and while these are laudable efforts in the reduction of risk, there are not effective pollution prevention control.

The science of chemistry has been recognized in recent times as a central point in addressing the problems facing the environment. Through the utilization of the various sub-discipline of chemistry and the molecular sciences, there is an increasing appreciation that the emerging area of green chemistry is needed in the design and attainment of sustainable development. A central driving force is this increasing awareness is that green chemistry accomplishes both economic and environmental goals simultaneously through the use of sound, fundamental scientific principles.

Chemistry itself has the power to tackle some of the 21st century society biggest and most interesting problems such as the synthesis and manufacturing of chemicals, protection of individuals through the development of sophisticated analytical tools, eco-friendly products and processes and creating awareness. Chemistry sustainability problems are determined largely by these economy ecosphere material flow which current chemistry education ignores.

To achieve such sustainable chemistry, it requires a change in the chemical community, classrooms and school laboratories. The principles of green chemistry must become an integral part of chemical education and practice. However, there are several obstacles to overcome. First, chemists and classroom teachers need to incorporate environmental consideration into decisions concerning the reactions and technologies to be developed in the laboratory. Secondly, it is critical that chemistry that is not really green does not get sold as such and that the public is not misled with false or insufficient safety information.

The introduction of green chemistry principles together with the fundamentals of chemistry in the early education of students by teachers could contribute to improving public opinion about chemistry which is generally perceived as everything that is artificial, dangerous and toxic(Allen 2004; LaMerill, parent & kirchhoff, 2013). It is the teacher's responsibility to emphasize the fact that chemistry is not essentially good or bad, the atomic and molecular knowledge of the surrounding environment, the reactions involved in natural processes and in bodily function are the basis of science which of course permits humans to produce and manage both natural and synthetic products. Green chemistry can play an integral role in moving society towards a more positive, sustainable direction (Klingshirn and Spessard, 2012). In dedicated advanced courses, chemistry teachers must challenge students to conceive the concept of green chemistry processes and become conversant with them by emphasizing through concept and example of how safe processes can be developed that are beneficial to man and the environment. It is therefore necessary to pass on the ethical and environmental aspects so that students can identify chemistry as a part of the solution to environmental problems and not only as one of the contributory agents of environmental change.

The challenge lying before green chemistry is to understand the principle forces, chemical-eco-system relations, educational needs and research imperative that sustainability brings centre stage and to merge this understanding as much as possible with economic maxims. If chemistry teachers direct the strength needed to contributing to a sustainable civilization, chemistry will become more interesting and compelling to people and may lose its toxic image. It will become more worthy of public support and spawn exciting economic enterprises that nurture sustainability. Green chemistry is an approach to the design, manufacture and use of chemical products to intentionally reduce or eliminate chemical hazards (Anastas P.J and J.C Warner,

1998). The goal of green chemistry is to produce a better, safer chemical while choosing the safest, most efficient ways to synthesize chemicals and to reduce wastes. Green chemistry dims at eliminating hazards right at the design stage and at the application stage.

Green chemistry however is one of the most fundamental of these fields in that it focuses on the molecular level to design chemicals and materials to be inherently non-hazardous. The challenge of promoting greater adoption of green chemistry innovations education is substantial because green chemistry is an emerging disruptive technology embedded in a complex scientific, political, regulatory, economic, industrial and cultural framework. In implementing an effective teaching, teachers should also integrate various teaching strategies which are suitable to the interest, talent and cognitive level of the students (Rusilawati and Zainon, 2009; Sharifah, 2011; MohdZohir 2008; Khor, 2006). One of the principles of green chemistry is to prioritize the use of alternative and renewable materials including the use of agricultural waste or biomass and non-profit related bio-products.

Green chemistry is not only implemented in the laboratory and the chemical industry, but also applied in the classroom. Development of green chemistry in chemical education has the ultimate goal of raising awareness, and the active participation of students and chemistry teachers to apply the basic concepts of green chemistry as part of the solution to environmental problems.

Van-Ejick (2007) stated that the implementation of green chemistry in the curriculum contributes as the general aims of science education, being an important element in the development of scientific literacy within the general public. Due to the importance of green chemistry in contemporary science and the recent drive towards sustainable development most developed countries and many developing countries have included the concept into high school and tertiary

school curriculum. This however has been done by these countries at different levels and to varying extents.

One of the arguments brought about by skeptics is that traditional materials are more important than green chemistry concepts and that there is not enough time to cover the mainstream concepts and introduce new areas. Poor attitude may also arise from teachers and lectures who may be reluctant to introduce green chemistry simply for the fact that they might not have been trained to do so or because they aren't yet convinced of its importance.

Another obstacle is the level of relevant curricular material. In fact, it is true that chemistry textbooks which refer to green chemistry are particularly lacking especially at the secondary level. However, there are several unlike publications suitable for teachers and some alternative educational resources which are available. Some teachers also view green chemistry as being either too political or not enough scientific and hence not as challenging as the traditional chemical science since the traditional science teaches us to accept the fact that handling of explosive toxic and so on as part of the process. Most times green chemistry has been termed by critics as being "soft chemistry" or "hippy chemistry".

Green chemistry is also viewed as not having on what it takes to train students on how to handle dangerous chemicals as it aims to minimize chemical hazards in laboratories and industry. Critics argue that students may eventually find it harder to deal with such chemicals at a future place of work. Green chemistry can only make significant progress once it is diffused in all areas of chemistry. This process can only be achieved by creating awareness and implementation of green chemistry in all levels of education starting from the lowest possible level, that is secondary education. The education of chemists and all those interested in chemistry is an ever-evolving

endeavor to keep up with the latest innovation, discoveries, concepts, perspectives and techniques of the field. This lies on the shoulder of the teacher.

Teachers play a key role in the implementation of green chemistry in schools but to do this with authenticity, they themselves needs to be environmentally aware have a certain level of awareness of green chemistry and have a personal and professional concern for the environment. Hence there is a need to measure the level of awareness and attitude towards the implementation of green chemistry among secondary school teachers who have gotten an aspect of green chemistry in their training.

Upon this background, it became pertinent to investigate the awareness and attitude of chemistry teachers towards implementation of green chemistry among secondary school teachers in Minna metropolis.

1.2 Statement of the Problem

When chemistry teachers teach their students about the compositions, outcome, mechanisms controlling forces and economic value of chemical processes, only 30-45% of teachers make emphasis on the possible dangers to human health and the ecosystem.

Globally, there is a growing requirement for cleaner processes and product leading to greener products and practices through green chemistry. So, an important basic education of young chemist on the principles and practices of green chemistry will be of a great interest for future professional activities and will provide tools for future professional activities and will provide tool for an appropriate selection of the best method and chemical for obtaining the best possible result with minimal or no environmental pollution.

The Nigerian curriculum for science and technology as recently amended tis expected to take care of the recent drive to environmental sustainability of which green chemistry is an integral part of. It is assumed that the practice of green chemistry is yet to gain acceptability due to poor knowledge of its concepts and principles. Although some progress has been registered in the integration and implementation of green chemistry principle and practice into the various levels of education including the secondary level, the situation is still considered far from being ideal. It is evident that there are a number of obstacles affecting the full implementation of green chemistry in schools.

Therefore, teachers have a primary role in educational system. The solution of this task is impossible without teachers. Teachers are in the forefront of implementation of green chemistry in Nigerian schools. Attitude, knowledge and application are three important domains for educational assessment. Teachers can provide comprehensive information as well as an overview of what is happening in the educational system. Anyone who remembers education remembers teachers and not methods and techniques. Teachers are the heart of the educational system.

Unfortunately, knowledge about secondary school teachers' awareness and attitude toward implementation of green chemistry is rare. In the case of Nigeria chemistry education particularly Minna, it is difficult to find. This study is an attempt to reduce this lack of information. It intends to measure the level of awareness and attitude of chemistry teachers towards implementation of green chemistry among secondary school teaches in Minna metropolis.

1.3 Aim and objectives of the Study

The study focused on determining the level of awareness and attitude of chemistry teachers towards implementation of green chemistry among secondary school teachers in Minna metropolis.

Specifically, the objectives of the study are to;

1. determine the level of chemistry teacher awareness of green chemistry.
2. measure the level of implementation of green chemistry in public secondary school in Minna metropolis.
3. determine the attitude of chemistry teachers towards teaching of green chemistry in Minna metropolis.
4. determine if gender has effect on the awareness and attitude of green chemistry practices.

1.4 Research Questions

The following research questions guided the study;

1. What is the level of awareness of green chemistry among chemistry teachers in public schools in Minna metropolis?
2. What is the level of implementation of green chemistry practices in public secondary schools in Minna metropolis?
3. What is the attitude of teachers towards teaching of green chemistry in public secondary schools in Minna metropolis?

4. What is the effect of gender on the awareness and attitude of green chemistry practices?

1.5 Research Hypotheses

The following null hypothesis guided the study;

$HO_{1:}$ There is no significant difference in the awareness of green chemistry between male and female chemistry teachers

$HO_{2:}$ There is no significant difference in the attitude towards green chemistry practices among male and female chemistry teachers.

1.6 Scope and limitation of the Study

The present study had some limitations. This study was limited to teachers of public senior secondary schools in Minna metropolis only. The study involved only chemistry teachers of public senior secondary school in Minna metropolis. The content scope was based on awareness and implementation of green chemistry practices.

1.7 Significance of the Study

This study will be of use to many stakeholders of education and the chemical industries. The groups who are likely to benefit are; teachers, students, curriculum planners, chemical manufacturers, on chemists and other researchers.

To the teachers this study will help them develop a green ideology and methodology when teaching chemistry in the classroom and in the laboratory by exposing them to the need to

practice the principles of green chemistry in order to save reagents and solvents and to replace the most toxic solvents by other less toxic ones.

To the students, it will help them in understanding the basis of green chemistry and their roles in protecting the environment making chemistry less abstract and more concrete by allowing them apply the principles taught or how to relate the theories, with the practical everyday living which will help boost their interest and motivation to learn chemistry at the secondary school level and beyond.

To the curriculum planners, it will help them in redesigning the chemistry curriculum in Nigeria to reflect environment consciousness and include basic green chemistry concepts in secondary schools to help bridge the gap between Nigerian and the developed countries.

To chemical manufacturers, it will help them in manufacturing chemicals based on the principles of green chemicals and make them more aware of the effect these have on the environment. To policy makers, it will help them in enacting laws to protect the environment by encouraging green products into the country like encouraging the importation of electric cars and ban the use of benzene in school laboratories.

To non-chemists, it will help them improve, have different opinion, idea about chemistry as everything that is dangerous and toxic by making them aware that chemistry is not only a causative agent of environmental problems. To textbooks authors, it will help them in presenting their text context to reflect how best the teachers can implement green chemistry practices by providing a verse information on green solvents and resources for teaching green chemistry.

Other researchers may use this report as a point of reference and a base for carryingout research in other related areas of education.

1.8 Basic Assumptions of the Study

The researcher assumed that the subjects responding to the survey answered the questions completely and honestly to the best of their knowledge.

1.9 Operational Definition of Terms

1. **Awareness**: It is the ability to directly know and perceive, to feel or to be cognizant of events. Idea of holding a general impression or consciousness about the environment and green chemistry

2. **Attitude:** To acquire values, feelings of concern and motivation towards the participation of green chemistry practices in schools and industries.

3. **Green Chemistry**: Green chemistry is the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products.

4. **Awareness about green chemistry**: To understand the knowledge about how hazard components of surroundings have been converted into eco-friendly and less toxic usually by following one or more principles of green chemistry.

5. **Knowledge**: To gain experience and a basic understanding of green chemistry and its practices.

6. **Traditional Chemistry**: This is the practice and method of teaching chemistry that allows students to handle toxic substances and have little regard on the effects of these chemicals to human health and the environment.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter gives the review of literature related to the study. It puts into perspective the concept of green chemistry and sustainability and the barriers of green chemistry. It goes ahead to give a brief history of green chemistry as well as studies on attitude and awareness of green chemistry. Theories of attitude and awareness were also reviewed at depth as well as other studies related to the present study.

This section is broadly sub divided into three namely;

i. Conceptual framework

ii. Theoretical framework; and

iii. Empirical framework

2.2 Traditional Ideas and Practise of Chemistry

The accepted status of chemistry as the central (enabling) science has progressively been augmented by a rich research history dating back over at least a half century. Traditionally, chemical education has been considered as a combination of three major dimensions. Over the last two decades, there have been some notable developments of these dimensions. With respect to curriculum design, Atkins (Atkins PJ, 2010) has proposed that ‘chemistry is based on just a few simple ideas’, which has not only led to finalizing the constitution of the long-debated ‘core of chemistry knowledge’ (Hill J. ,2010), but also to the reevaluation of the content and context of secondary and tertiary chemistry courses in conjunction with more effective learning strategies.

Also, Fensham (Fensham PJ, 1984) proposed that 'science has social responsibilities', which has been interpreted by Hill (2010) from a chemistry perspective. Furthermore, with respect to addressing a new vision for secondary basic chemistry courses, Hill (Hill ,2006) has designed a curriculum framework for these courses which embraces the proposals of Atkins (Atkins PJ,2010) and Fensham (Fensham PJ, 1984) and which leads to defined learning outcomes.

However, it should be noted that "chemistry knowledge" alone is not sufficient to resolve issues such as toxic waste disposal, climate change consequences and nuclear energy concerns (Sarewitz, 1996). Chemical education is critical as education is an essential element of all aspects of a transition to sustainability. With respect to teaching methodologies, Bedgood (Bedgood 2006) has asked, 'Why are we still teaching (Chemistry) the way we were in the 1980's?' He has been involved in a pioneering project aimed at enhancing science learning and teaching in Australian universities with a focus on first year science programs, which are characterised by large numbers of student participants, didactic teaching methods and multi-cultural learning environments. This program is piloting student-centred teaching methodologies in conjunction with student group learning strategies, fostering knowledge accumulation and enquiring minds. But such well-intentioned ideas for learning chemistry are often met with challenges in the wake of more computer-oriented online approaches to teaching chemistry. With respect to learning strategies and objectives, Mahaffy (Mahaffy, 2010) has shown that there is an integral connection between chemical reactivity and human activity, and proposed that the traditional three levels of learning chemistry – 'macroscopic', 'symbolic' and 'molecular' – be extended to a fourth dimension 'human element'.

Mahaffy (Mahaffy, 2010) has campaigned for the integration of environmental sustainability into chemical education consistent with chemistry being an integral influence on the global future of

humanity in terms of secure energy supplies, and the consequences of climate change and of diminishing food and fresh water resources.

Thus, it appears that a new vision for chemical education is required, encompassing many new dimensions, if it is to address the challenges inherent in engaging environmental sustainability. It is evident that sustainable chemistry education involves different methodologies in teaching fundamental chemistry concepts, whereby new terms and new philosophies are introduced. For example, chemical systems involving multiple chemical reactions need to be discussed in addition to examples of different types of single chemical reactions. Furthermore, chemical reactions need to be discussed in terms of 'atom economy' to illustrate the principle of chemical efficiency. The core topic of thermodynamics needs to be discussed in terms of energy efficiency of chemical processing and manufacture in addition to energetics and spontaneity of chemical reactions. The core topic of kinetics needs to be discussed in terms of selective catalysts, which maximise product yield by decreasing by-product formation. Such discussions interlink core chemistry knowledge with green chemistry principles and form the foundation on which sustainability of the chemical enterprise is progressed. As a consequence of such inclusions in chemistry curricula, suite of new terms emerges such as 'feedstock' replacing 'reactant' and 'E-factor', which is the ratio of the mass 'waste' compared to that of 'product'.

In conclusion, since 'sustainability' and 'sustainable development' are complex, multi-dimensional' concepts, sustainable chemistry is also multi-dimensional in character, embracing disciplines not normally aligned with it such as economics, accounting, humanities, sociology, cultural studies, health sciences, food science and agricultural science. Hence, successful engagement of chemical education with sustainability involves developing partnerships with these disciplines to form a united educational platform for moving towards environmental

sustainability. Fundamentally, sustainable chemistry education is a powerful philosophy integrating 'chemistry' into the 'sustainable future' syndrome and offers challenging educational opportunities to achieve identifiable sustainable outcomes.

2.3 Concept of Green Chemistry

Green is a strong colour. Green is the colour of chlorophyll being green has long been a battle cry of environment activists and being green has become an importance marketing tool for business. The term Green Chemistry is defined as "The invention, design and application of chemical products and processes to reduce or to eliminate the use and generation of hazardous substances"(P.T. Anastas and J. C.Warner, 2008). While this short definition appears straightforward, it marks a significant departure from the manner in which environmental issues have been considered or ignored in the up-front design of the molecules and molecular transformations that are at the heart of the chemical enterprise. Looking at the definition of Green Chemistry, the first thing one sees is the concept of invention and design. By requiring that the impacts of chemical products and chemical processes are included as design criteria, the definition of Green Chemistry inextricably links hazard considerations to performance criteria.

Another aspect of the definition of Green Chemistry is found in the phrase "use and generation". Rather than focusing only on those undesirable substances that might be inadvertently produced in a process; Green Chemistry also includes all substances that are part of the process. Therefore, Green Chemistry is a tool not only for minimizing the negative impact of those procedures aimed at optimizing efficiency, although clearly both impact minimization and process optimization are legitimate and complementary objectives of the subject.

The definition of Green Chemistry also illustrates another important point about the use of the term “hazard”. This term is not restricted to physical hazards such as explosiveness, flammability, and corrodibility, but certainly also includes acute and chronic toxicity, carcinogenicity, and ecological toxicity. Furthermore, for the purposes of this definition, hazards must include global threats such as global warming, stratospheric ozone depletion, resource depletion and bioaccumulation, and persistent chemicals.

Green Chemistry definitions change based upon focus. Green Chemistry is often described within the context of new technologies but Green Chemistry is not beholden to ionic liquids (Seddon K,2002)microwave chemistry, supercritical fluids, bio transformations, fluorous phase chemistry, or any other new technology. Green Chemistry is outside of techniques used but rather resides within the intent and the result of technical application. Green Chemistry is a concept for scientists envisioned by scientists for higher efficiency, not a mandate or a condemnation from outside of the scientific community. In short, Green Chemistry is neither a new type of chemistry nor an environmental movement, a condemnation of industry, new technology, or “what we do already”. Green Chemistry is simply a new environmental priority when accomplishing the science already being performed... regardless of the scientific discipline or the techniques applied. Green Chemistry is a concept driven by efficiency coupled to environmental responsibility.

Green Chemistry is defined as environmentally benign chemical synthesis. Green Chemistry may also be defined as the invention, design, and application of chemical products and processes to reduce or eliminate the use and generation of hazardous substances. The synthetic schemes are designed in such a way that there is least pollution to the environment. As on today, maximum pollution to the environment is caused by numerous chemical industries. The cost involved in

disposal of the waste products is also enormous. Therefore, attempts have been made to design synthesis for manufacturing processes in such a way that the waste products are minima, they have no effect on the environment and their disposal is convenient. For carrying out reactions it is necessary that the starting materials, solvents and catalysts should be carefully chosen. For example, use of benzene as a solvent must be avoided at any cost since it is carcinogenic in nature. If possible, it is best to carry out reactions in the aqueous phase. With this view in mind, synthetic methods should be designed in such a way that the starting materials are consumed to the maximum extent in the final product. The reaction should not generate any toxic by-products.

The concept and ideal of Green Chemistry now goes beyond chemistry and touches subjects ranging from energy to societal sustainability. The key notion of Green Chemistry is ‘‘efficiency’’, including material efficiency, energy efficiency, man-power efficiency, and property efficiency (e.g., desired function vs toxicity). Any ‘‘wastes’’ aside from these efficiencies are to be addressed through innovative Green Chemistry means. ‘‘Atom-economy’’(Trost B,2001) and minimization of auxiliary chemicals, such as protecting groups and solvents, form the pillar of material efficiency in chemical productions.

2.3.1Historical Background of Green Chemistry

Carson was the first to raise environmental awareness about the unintended damage caused by pesticides which led to the introduction of environmental legislation in the US (Hogue,2013). Until the 1960s there were no environmentally-related regulations on the manufacture, use and disposal of chemical substances and pollution used to be controlled by reducing the concentration of the pollutants in a medium, a strategy described as ‘dilution is the solution to pollution’ (Anastas & Warner, 1998). The situation however changed drastically with the widely publicised environmental disasters and an ever growing public concern and knowledge on chronic toxicity,

bioaccumulation, carcinogenicity and other health related issues on the use and exposure to chemicals. Different countries started reacting by adopting different approaches to safeguard human health and the environment from risks posed by the production, use and ultimate disposal of chemical substances. According to Cann (2001), by the year 1990 the U.S.A. alone had sanctioned no less than 130environmental laws dealing with the treatment or capture of pollutants at source.

The new pollution prevention legislation in the U.S. set the stage for the emergence of the green chemistry movement as the U.S. Environmental Protection Agency launched its first research initiative in 1991, focusing on pollution prevention in the synthesis of chemicals.

The programme was originally called 'Alternative Synthetic Pathways for Pollution Prevention' but was officially renamed in 1993 as the 'Green Chemistry Program'. The aim of the programme was to implement sustainable development in chemistry and chemical technology through the collaboration with a number of organisations representing academia, the industry, government agencies and NGOs (Lancaster 2002; Newton, 2008;OPPT, 2002; Pellerin, 2005; Wardenchi et al, 2005).

It is widely recognised that 'green chemistry' as a concept was introduced for the first time in the early 1990s by Paul V. Anastas, one two authors of the first handbook in green chemistry (Anastas & Warner, 1998). This new philosophy was originally referred to as 'benign by design chemistry' or simply 'benign chemistry' but then changed to 'green chemistry' (Linthorst, 2010), a shift regarded by Roberts (2005) as deliberate as it is difficult for a chemical process to be truly and completely environmentally benign.

The US green chemistry research programme served as a platform and catalyst for the major green chemistry events in the USA and beyond. These included symposia, conferences and the prestigious US Presidential Green Chemistry Challenge Award which was established in 1995 to recognise outstanding achievements in green chemistry (Fairley, 1998; National Environmental Health Association, 1997; Newton, 2008; OPPT, 2002; USEPA, 2010).Another important milestone in the history of green chemistry was the launching of the Green Chemistry Institute (GCI) in 1997 to support collaboration between industry, universities,(US) national laboratories and other organisations in order to promote and advance green chemistry and green engineering. The GCI, which joined the American Chemical Society (ACS) in 2001, is now regarded also as an international network of green chemistry expert and is represented in no less than 25 other countries, across all continents, through a number of international affiliate chapters.

Green chemistry activity started also proliferating in other parts of the world in the late 1990s with the setting up of various green chemistry centres, institutes and networks mostly based in prominent universities. A number of countries (such as Italy, UK, Japan, Canada and Australia) also launched their national awards in green chemistry, similar to the US Presidential Award in a bid to promote further research in green chemistry. Europe launched its own international award scheme known as the European Sustainable Chemistry Award in 2010 through the European Association for Chemical and Molecular Sciences (EuCheMS 2010).

One of the first and perhaps the most influential publications in green chemistry was the previously cited book ‘Green Chemistry: Theory & Practice’ published by Warner and Anastas in

1998. This book practically gave life to green chemistry by giving it a precise definition and by introducing the 'twelve principles' as the main framework for the application of green chemistry. Since then, the book has been translated to several languages and marked the 1990s as the decade when green chemistry was established as a legitimate scientific field (ACS, 2014b; Warner & Anastas, 1998).Another important event for green chemistry was the launching in 1999 of the first international scientific journal dedicated to green or sustainable chemistry. This journal, named 'Green Chemistry', was published by the UK Green Chemistry Network which was founded in the previous year by the Royal Society of Chemistry. The journal 'Green Chemistry' was later joined by several other peer reviewed international scientific journals also specialising in green chemistry.

Two international organisations which are quite active in green chemistry are the Organisation of Economic Cooperation & Development (OECD) which established its own 'Sustainable Chemistry' programme in 1998 and the International Union of Pure & Applied Chemists (IUPAC) which launched a biannual international conference on green chemistry in 2006. Green chemistry research activity earned the international limelight in the early 21st century with the awarding of the Nobel Prize in chemistry in 2001 and 2005 to a number of chemists for their research into areas largely associated with green chemistry (Nobelprize.org, 2015).

Green chemistry was also influential in updating legislation on the production, use and circulation of chemicals around the world. An example is the important legislation recently introduced by the E.U. and known as the REACH Directive (standing for Registration, Evaluation, Authorisation & Restriction of Chemicals) which entered into force in 2007(European Commission's Directorate General for Enterprise & Industry, 2014). This European legislation has been described as a

'major shift towards green chemistry' (Morson, 2007) as it encourages the development and use of chemicals that are harmless to human health and the environment. James Clark, another leading figure in green chemistry, described REACH as 'the most important chemicals-related legislation in living memory'. He suggests that apart from protecting public health and the environment, this EU directive allows European producers of chemicals to claim a high level of 'green credentials' to those products evaluated for toxicity and environmental impact, giving a competitive advantage over others in the world.

2.3.2 Developing Countries and Green Chemistry

In developing countries, the introduction of green chemistry is still in its infancy stage, despite the significant role green chemistry can play. Any of the practices in developing countries are still far from the concepts of safety, pollution prevention and design of energy efficiency. Environmental pollution and waste generation (Okonkwo, Okunola and Ezeanyanaso 2010) are some of the aching problems many developing countries are suffering from. Many of the reasons behind these problems lie in policies and strategies adopted that are based on end of pipe treatment. Most frequently, income generation activities are dependent on an efficient use of energy and other resource such as water which may pose some serious problems to future generation.

According to (Okonkwo, Okunola and Ezeanyanaso, 2010), the united Nations reporting on the millennium development goals at a country level, indicated a high level of energy consumption and limited energy resources in most of the developing countries. This report strongly recommended the imperative need to ration the use of energy resources in these countries and to implement energy conservation policies. The same trend of difficulties developing countries face

has been illustrated in the series of country reports produced by the rural development of the water and environment department of World Bank (Okonkwo, Okunola and Ezeanyanaso, 2010).

Green chemistry could play a pivotal role in salvaging many of the ailing conditions that many of the developing countries like Nigeria are subjected to. The use of solar energy, introduction of sustainable farming, recycling and the implementation of life cycle thinking and life cycle analysis as a management tool for some of the chronic issues such as municipal waste management, are of few examples of how green chemistry can benefit developing countries. Green chemistry can also have a very strong impact on water sufficiency issues in that part of developing countries where water resources are polluted. It is through the implementation of a cleaner production and the use of safe and biodegradable chemical that a huge volume of waste water could be reused to provide the emerging critical need of water in many of these countries.

The first green chemistry workshop in Africa was held in Ethiopia in North Africa and was jointly organized by the schools of chemistry of both Addis Ababa University (AAU) and the University of Nottingham (VoN) in association with chemical society of Ethiopia (CSE).the objective were firstly to create awareness among academics and professionals in the country and secondly to sensitize the policy makers to the role of green chemistry in environment sustainability. Much current research is focused on the search for renewable feedstock and more environment acceptable solvents as replacements for petroleum-based product. This makes green chemistry particularly relevant to the needs of African country such as Nigeria which is faced with an increasing demand for chemicals and rapidly expanding population (Pan African, 2011).

A Pan African Green Chemistry workshop was later held in South Africa in 2007 as a result of this, a group of researchers in South African have studied the chemistry of coordination

compounds in solvent free medium and ionic liquid in order to avoid the traditional volatile organic solvents which are considered as carcinogens (Christopher, Vicent and Thomas, 2004; Christopher *et al*, 2002; Christopher *et al*,2005).

The first workshop on Green Chemistry in Nigeria was held in 2008 and in 2009 the chemical society of Nigeria held its annual conference in Abeokuta Nigeria with Green Chemistry as the major theme consequent upon this application of green chemistry is already being explored though at its infancy stage (Okoro and Okon 2011; Okonkwo, Okunola and Ezeanyanaso, 2010)

Compared to developed nation of the world and other parts of Africa and judging from the fact that Nigeria is a large market for chemicals and toxic technology in the continent it is sad to note that there is yet to be a strong initiative and infrastructure in place to develop green chemistry in Nigeria (Adeoye, 2012)

Developing countries that are rapidly constructing new chemical manufacturing facility have an excellent opportunity to apply the catch phrase of green chemistry being by design from the ground up wards. It is easier to build a new, environmentally compatibles plant from scratch than to have to deconstruct there reconstructing as in the case of developed world.

2.4 Green Chemistry Education and Sustainability

Green Chemistry is today considered as one of the key scientific solution to the problems of environment, that is environment degradation and sustainability. It is vital that teachers are sufficient equipped with the knowledge of contemporary chemistry which support sustainable development and also safeguard the environment and human health. All this can be guaranteed by

providing green chemistry education to future chemist and chemistry teachers starting from the school.

It is becoming increasingly important that the school chemistry curriculum allows space for the introduction of the fundamental principle and some aspects of green chemistry (Oloruntegbe & Agbaylwa, 2003). This provide a good opportunity for students to know that chemistry is changing in such a way that it is becoming more eco-friendly by marrying on the development of non-toxic and polluting chemical and chemical processes (Oloruntegbe 2003) Oloruntegbe (Oloruntegbe, 2003) also opined that students are particular sensitive to environment issues and so, adding the basics of green chemistry may also serve to boost their interest and motivation to learn chemistry at the secondary level and beyond.

Green chemistry has been purpose establishing in the early 1990s in order to design safe chemical products and processes for a more sustainable future. Rather than being viewed as a new branch of science, it is considered as a new philosophy or a new way of thinking that has the potential to contribute to sustainable development (Lancaster, 2001; Wardenchi et'al, 2005)

Talor (2010) regards green chemistry as a revolutionary change in preventing pollution and health problems starting at the chemical stage. Hence, to play an important role as environment sustainability educationist, chemistry teacher need to equip themselves with ample knowledge and skills to disseminate the comparative green practices to their students.

The emergence of green chemistry in the 1990s was followed by the growing need of the exponent in this field to share new philosophy and methodology of doing chemistry with other chemist and student aspiring for a chemistry career. Infact, education was soon recognize as the

ideal medium through which the green chemistry message could be diffused among University Students and the society (Warenchi *et'al*, 2005).

Educators started looking at ways and means of integrating the green chemist concept with those of sustainable development which were developed a few years earlier and teach them in different level of education. This is because green chemistry usually shares the ideals of sustainable development that is why green chemistry is sometimes referred to as sustainable chemistry.

Teaching green chemistry is one way of showing the importance of chemistry for sustainable development (Burmeister & Eilks, 2012). Others authors also mentioned a number of benefits associated with the introduction of green chemistry to empower young students to relate traditional chemistry concepts that are taught in class to the real world outside and possibly to a future career in chemistry too, given the choice students have to make at this age (Brain *et'al*, 2006) learning green chemistry allows also students to connect chemistry with others school subject and aspect of their VAS (Goes *et'al*, 2013; Karpudewan *et'al*, 2012).

Countries like the USA, UK and Australia have started promoting and teaching some basic concepts of green chemistry in secondary schools in order to show student what chemistry can do for a sustainable future such a move is consistent with the new trend of contemporary secondary and post-secondary science and chemistry curriculum which recommend teaching of basic ideas of sustainable development to prepare students to become better citizens and future expect of science (Bradley, 2012).

The body of this literature surveyed points to the facts green chemistry can only make significant progress once it is diffused in all area of chemistry in order to reach all chemist. This process can

only be achieved by integrating the principles of green chemistry in all levels of education starting from the lowest possible level (Eilks & Rauch, 2012).

Green chemistry is not expected to take chemistry student completely by surprise. Indeed, some authors see it as the next logical step following the earlier introduction of environment chemistry into most chemistry programmes. In relation to environmental sustainability, green chemistry is one approach which focuses on giving contribution for the sustainable environment throughout minimizing the using of chemical substances. Therefore, in laboratory, green chemistry approach will help to reduce the cost of using less quality of chemical substances.

There are several important respect in which green chemistry is sustainable.

a. **Economic:** At a high level of sophistication, green chemistry normally cost less strictly economic term than chemistry as it is normally practiced.
b. **Materials:** By efficiently using materials, maximum recyclic and minimum use of virgin raw materials, green chemistry is sustainable with respect to materials
c. **Waste:** By reducing as much as possible or even totally eliminating their production, green chemistry is sustainable with respect to waste

As for sustainable development, there have been many definition of green chemistry which relates to the production of environment friendly product and substances such reduce or eliminate the product of waste (Hearn, 2008) these definition implies that green chemistry and sustainable chemistry are closely inter related since the vision of green chemistry completely aligned with environmental sustainability.

2.5 Barriers to the implementation of green chemistry

Although some progress has been registered in the integration of green chemistry in the curricula of both secondary and university courses, the situation is still considered far from being ideal (Braun et al, 2006; Cann, 2001; Kirchhoff, 2009). In fact, to date, green chemistry still does not form part of the standard chemistry curriculum in most colleges and schools (Matus, Anastas & Zimmerman, 2012). It is evident that there are a number of obstacles which need to be addressed for a broader implementation of green chemistry in education.

One challenge with understanding the barriers to these particular technologies is that it can be difficult to disaggregate the barriers particular to green chemistry and green engineering, and those that would complicate innovative activities more generally. There is limited literature on the barriers to these particular kinds of innovations in the Nigerian context.

From the innovation literature (Gatignon et al., 2002; Lall and Pietrobelli, 2002; Poliakoff et al., 2002; Archibugi and Pietrobelli, 2003; Tushman and Smith, 2004), there are several main areas where barriers to innovation are typically located. They are

1. *Organizational barriers*: These involve the ability of those in the firm to search and access appropriate innovations, and also to have a structure (including managerial and technical capabilities) that supports both experimentation and search;
2. *Economic and financial barriers*: These are the barriers that arise from the capital constraints of the firm. There are a variety of costs associated with innovations, beyond the cost of development itself, and they may exceed the expected payoff;
3. *Cultural barriers*: There are nations, industries, and firms that are resistant to new technologies, or lack a culture that provides incentives for innovative activities;

4. *Regulatory barriers*: These occur when regulatory requirements lock firms into particular technology approaches, or when tax or other structures are not favorable to investments in innovation;
5. *Market barriers*: In markets with many competitors, it may be difficult for innovators to recoup the cost of their investment, especially if there is a low value-add to their products. Network effects, monopolies, and other market failures can also create barriers;
6. *Path-dependence barriers*: Innovators are often constrained by earlier investments made by firms and industry into particular technological platforms and processes. The need to interface with existing infrastructures can present a barrier to the development and deployment of new technologies. This can be a particularly important barrier to innovation in some parts of the chemical industry.

2.6 Promoting Green Chemistry Education

Based on Tbilisi's declaration, green chemistry education should prepare opportunity for people to participate in processes to solve environmental problems and create a sense and commitment among student than to the living environment (Yarkanai A.H and Yarkandi N.H, 2012).

Since the nature of chemistry lessons is very unattractive to student (Allen, 2004), teachers need to manipulate investigative and research-like approaches to trigger and enhance student awareness of green chemistry. Armed with green chemistry as the platform, chemistry experiences encourage students to embark on research and seek information on green chemistry practices. Culifer (2000) opined that student understanding of green chemistry was significantly enhance when presented with two real world scenarios applied profit-cost-risks analysis that empahasizes a decreasing depending on limited non-renewable source and an increasing focus preventing pollution by products of the chemical industry.

Iyengar (2007) suggested that reorienting education for sustainable development was a proposal that is useful, but needs consideration in each country differently. Pardiwela (2005) revealed that the much needed relation between people and nature cannot taught through text book within the conframe of a classroom people must be taught the art of living environmentally sustainable lives right from their childhood.

The concept of sustainability which is borne by green chemistry should be socialize and introduced at every level of education (wardencki *et'al*, 2005). Green chemistry will ensure the creation of a new generation of chemists possessing the skills and knowledge to practice environmentally friendly chemist (Hjeresen *et'al*, 2005) green chemistry will ensure the creation of a new generation of chemists possessing the skills and knowledge to practice environmentally friendly chemist (Hjeresen *et'al*, 2000).

Education and teaching chemistry in accordance with the paradigm of green chemistry require work and planning, integrating the principles of green chemistry try into learning process through conventionally teaching in terms of thinking about green chemistry is not evident (santosa and sri, 2008).Wardencki agree and suggested that the success of green chemistry depended on the training and education of a new generation of chemist (wardencki *et'al* 2005).

It would be hard to expect student to have knowledge of green chemistry if teacher do not have that understanding and could not see that green chemistry needed to be integrated into the process. The positive perception of chemistry teacher about green chemistry in learning process, will lead teacher to act and behave in accordance with the expectation of the principles of green chemistry. If this is the case, then the attitude and the behavior will be transmitted to student

however, result showed that only 31:386 of teacher believed that principles of green chemistry should be integrated in chemistry teaching and learning process.

A transformation to green chemistry technique would result in safer workplaces for industry workers, greatly reduced risks communities and safer and better substitutes product and chemicals for use in schools and laboratory as well as save money on waste disposal. The question of how to educate the future generation of chemists possessing the skill and knowledge to practice environment friendly chemistry, in the center of educational material related to green chemistry (Hjeresen, Schutt, Boese, 2000).

Further adoption of green chemistry could improve the public perception of the field of chemistry as a whole (Logar, 2011) promoting green chemistry research and its adoption into education through federal and state policies and education right help the field of chemistry bridge the gap between its value and those of the public, thus the growth area such as public perception chemistry, protecting our planet and environment and economic development.

The concept of green chemistry can be promoted and taught at different levels of education and serve as the ideals medium to portray a fresh and positive image of chemistry in all classrooms and school laboratories right from the secondary level.

2.6.1 COLLABORATION AND SECTOR ACTIVITIES

Government, academia, industry, and NGOs are key actors in promoting and implementing sustainable chemistry.

2.6.1. Role of Government:

Government can promote sustainable chemistry by:

i. establishing and funding programs on sustainable chemistry

ii. supporting efforts to inform industry and educate the general public of the importance and benefits of sustainable chemistry.

2.6.2 Role of Academia:

Academic institutions are responsible for preparing students to enter the professional workforce with the appropriate skills to work in a professional capacity. Incorporating green chemistry principles into the core required courses of chemists graduating with undergraduate or graduate degrees provides a set of tools for better designing molecules, products and processes. Green chemistry is by nature practical and applied chemistry, and therefore can provide an innovative platform for students entering the scientific workforce.

All academic institutions, including community colleges, four-year colleges, graduate institutions secondary institutions and teaching colleges, have a role to play in preparing a workforce with green chemistry skills. Community colleges serve to prepare a technician level workforce, which is essential for businesses to reside within a region, while pre-service teacher training programs are a critical piece to introducing future teachers to basic green chemistry principles.

Academia can promote sustainable chemistry by:

i. assessing the impacts of chemical technologies on human health and the environment.

ii. engaging in practical and cutting-edge research applicable to industrial processes and products,

iii. educating and training scientists, managing directors, and other workers in the chemicals industry, as well as students, about the importance of sustainable chemistry.

2.6.3 Role of Industry

Industry can:

i. design, develop, and manufacture products, benign for Human Health and the Environment

ii. continually improve manufacturing processes and products,

iii. provide society with product data relevant to human and environmental impacts.

2.6.4 Role of Professional Societies and NGOs

NGOs can:

i. disseminate information on sustainable chemistry research and results and on how those results meet societal objectives,

ii. establish criteria for international standards for assessing sustainable chemistry

iii. provide awareness to and act as an interface between the scientific community and the public.

2.7 Educational Resources for Teaching Green Chemistry

The amount of literature on green chemistry that has been published since its emergence in the early 1990s is substantial and reflects the growing interest and volume of research carried out in this new area of modern science. Yet the number of educational resources particularly textbooks that have been developed to date which target university and secondary school students and teachers are not so abundant. In fact, most of the teaching resources that have been created to date are more addressed to undergraduate and postgraduate students than to secondary school students (Cann & Dickneider, 2004; Hjeresen at al, 2000; Ware, 2001).

2.7.1 Online Resources on Green Chemistry for Pre-University Students

Name of Online Resource Description and Source

1. Beyond Benign. A website managed by the non-profit organisation 'Beyond Benign' which aims to revamp the teaching of chemistry so that students would connecting a better way with the world and be able to relate chemistry to human health and the environment. It includes various resources and programmes aimed for K-12 science, university and professional level.

2. Chemistry is All Around Network. This is a EU project forming part of the Lifelong Learning Programme which promotes the studying of chemistry at school. The portal provides a number of teaching resources and other online material which promotes teaching chemistry in a more innovative, attractive and interactive way. It was launched in 2012 and includes a website dedicated to green chemistry teaching resources (including original experiments) aimed for upper secondary schools. Though the main language is Greek, most of the material is translated to English.

3. Green Chemistry Educational Network (GCEdNet). This is a social network for educators, provided by the University of Oregon, USA, to support opportunities to research, develop, implement and disseminate green chemistry educational materials.

4. Green Chemistry Network (GCN). Based at the University of York, UK, and originally funded by the Royal Society of Chemistry, the GCN provides a list of useful information on green chemistry issues, of possible use in different levels including A-level and GCSE level.

5. Greener Education Materials for Chemists (GEMs). This is an interactive collection (database) of green chemistry resources compiled by the department of chemistry of the University of Oregon, USA. It includes laboratory exercises, lecture materials, course syllabi and multimedia content illustrating the green chemistry concepts. The level of material varies as it targets different audiences including the general public, secondary schools, colleges and universities. (University of Oregon, 2014).

6. Greener Industry. A website produced by the Chemical Industry Education Centre and supported by a number of organisations including the Royal Society of Chemistry, with contents being very relevant to the A-level curriculum, illustrating a number of products and processes of the chemical industry that can be rendered sustainable through green chemistry.

7. Online Educational Resources for Green Chemistry & Engineering. A website provided by the American Chemical Society featuring several links to a number of resources developed by the Green Chemistry Institute and the Education Division of the ACS. Resources include various teaching tools and ideas, and a number of activities and experiments in green chemistry designed for high school students and other levels of education.

2.7.2 Books for Green Chemistry Lecture Courses

There are several resources for people interested in learning more about green chemistry experiments they include.

1. Green Chemistry: Theory and Practice by Anastas and Warner. This book is the original source of the 12 Principles of Green Chemistry and provides illustrations of each of the principles. It includes case studies of greened technologies and highlights of green chemistry research up to 1998. Student exercises for each chapter are also included.

2. Real-World Cases in Green Chemistry by Cann and Connelly. This book discusses selected Presidential Green Chemistry Challenge Award winners, covering a broad range of chemistry topics. Ithas been used in many green chemistry lecture courses to highlight some ofthe most successful applications of the 12 Principles of Green Chemistry and their relevance to everyday life.

3. Introduction to Green Chemistry by Matlack. This textbook contains hands-on activities and more than 5,000 references.

4. Green Chemistry: An Introductory Text by Lancaster. This textbook includes some green engineering material and addresses policy issues. Discussion questions are provided at the end of each chapter.

5.*Going Green: Introducing Green Chemistry into the Curriculum,* edited by Parent and Kirchhoff. Designed for faculty members, this book provides an overview of green chemistry and sustainability issues and goals and gives examples of how other educators have introduced those themes into the chemistry curriculum.

6. Green Chemistry and the Ten Commandments of Sustainability, 2nd ed., by Manahan. This book describes the design of safer chemicals and the impacts of chemistry on air, land, and water. It introduces industrial ecology and discusses renewable feed stocks and alternative energy sources.

2.7.3 Books for Green Chemistry Laboratory Courses

1. Greener Approaches to Undergraduate Chemistry Experiments, edited by Kirchhoff and Ryan. This book is a compilation of 14 organic chemistry laboratory experiments, including pre- and post-laboratory assignments and discussions of how the experiments were designed to be green. It is freely available through the GEMS database

2. Introduction to Green Chemistry, edited by Ryan and Tinnes. This teaching manual contains a collection of laboratory activities that illustrate the 12 Principles of Green Chemistry.

3. Green Organic Chemistry: Strategies, Tools, and Laboratory Experiments by Doxsee and Hutchison. This book provides green experiments for teaching common organic chemistry

laboratory principles, such as solvent-free reactions, molecular modeling, atom economy, catalysis, and waste prevention.

2.8 Concept of Awareness

Awareness and consciousness are in some respect synonymous. The Longman Dictionary of contemporary English (2009) defines awareness as the knowledge or understanding of a particular subject or situation, the ability to notice something using sense and also refers to someone's idea, feelings or opinions about life, while consciousness is also defined by the above source as the condition of being awake and able to understand what is happening around you, the state of knowing that something exists or is true, and also implies someone's ideas, feelings or opinions about life politics, environment, water etc.

Chinedu (2008) viewed awareness as the conditions of being aware and able to understand what is happening around one. In agreement with the above views, Wikipedia (2009) equates awareness with perception of, conscious of, acquaintance with, enlightenment with, mindfulness of, cognizance of something. In the context of this study and in agreement with the above views, awareness implies understanding and knowledge of the activities and events (such as water conservation, usage, purification etc.) going on around one's environment.

2.8.1Awareness and knowledge of Green Chemistry

Green chemistry helps to achieve awareness, knowledge and responsible behavior about the environment. It has been defined and reviewed over the years. Regarding knowledge, Palmer (1998) emphasized that people should acquire appropriate range of knowledge, understanding, and concepts about the environment so that critical judgment can be achieved. These three

components awareness, knowledge and attitude play an important role on the impact people will have throughout the life inside and outside the classrooms

Orr (1992) reflected upon the forming altitudes in order to build on ecological literacy. This ecological literacy should not be interpreted as the knowledge necessary to facts and concepts only, but the knowledge necessary to comprehend interrelatedness, and attitude of care or stewardship. Madsen (1996) emphasize the concept that awareness is the ultimate driving force that stimulates knowledge the acknowledge that these is a need to turn to a better alternative of doing chemistry entails being more cognizant of the facts about the state of the environment. This degree of environment awareness involves a personal commitment to work to solve environmental problems" (p.72). He emphasized three powers behind the awareness factor by categorizing three levels of awareness as: basic belief of environment problems, factual and scientific knowledge and a commitment to solve environment problems.

Athman and Monroe (2000) stated that awareness and knowledge of green chemistry plays an important role in chemistry and the environment however these are not the only factor affecting the behavior outcome. Research has been conducted to evaluate objectives of green chemistry focusing mostly on the level of knowledge and attitude of teacher (Mosely, Reinke, & Diamond, 1999; Rovira, 2000; CoHrell, 2003). Sometimes, attitude has been interpreted as behavior (Pooley& O'connor, 2000) whereas, awareness has interpreted as concern (Krause 1993).

Stephen (2009) investigated sustainable development concepts such as green chemistry the target group were teacher at the secondary level. The result showed that the concept of sustainability can be developed by suitable learning experiences and project. Aminrad (2010) evaluated the awareness and attitude of university student. The result revealed that environment awareness was

moderate while attitude was high. Green chemistry is rather new in Nigeria. Studies have shown that some teacher could not even tell what green chemistry is all about or how to practice it green chemistry is mostly seen as environment chemistry which is not true.

Rajeswari (2010) conducted an investigation to measure the level of awareness and classroom practices of green chemistry. The finding revealed that most of the teacher had little awareness regarding the concept of green chemistry.

2.9 Concept of Attitude

Attitude according to Abini (2006) is an acquisitioned tendency, Abini further explained that pupils form attitude through either like or dislike, favourable or unfavourable towards event(s) in the environment. Good (2001) defined attitude as a state of mental and emotional readiness to respond to previously conditioned or associated stimuli. Williams (2000) described attitude as readiness to act in a certain way expressed by person's words, gesture or facial expressions. The above view is upheld as action at times speaks louder than voice. Kent (2002) noted that attitudes is a mental and natural state of readiness organized through experience exerting a directive or dynamic influence upon the individual's responses to all object and situation with which it is related. Therefore, attitude means the way of thinking and acting by individual towards a particular phenomenon or concept.

A fairly easy to understand definition is that attitudes represent what one likes and dislikes (Blackwell et. al, 2001), or the amount of positive and negative feelings one has towards an object. (Schlenker, 1978) A consistent number of authors (Schlenker, 1978; Fishbein & Ajzen, 1975; Insko & Schopler, 1967; Peabody, 1967) expand and define attitudes as learned tendencies when responding to an object in a 28 consistently favorable or unfavorable manner. Ajzen &

Fishbein (1977), Peter & Olson (1999) add to the main idea behind attitudes by defining the notion as a person's overall evaluation of a concept. Recent studies of Ajzen (2008) place the evaluation at the core of a person's attitude. In a more scientific manner, Thurstone (1928) affirms that attitude denotes "the total sum of a man's inclinations and feelings, prejudice or bias, pre-conceived notions, ideas, fears, threats, and convictions about any specified topic." One of the most extensive researches made on the specific concept of attitude is done by Doob (1947), who takes defining attitude seriously, especially for the fact that so few do in papers. He defines attitude in a more complex way, “as an implicit, drive-producing response considered socially significant in the individual's society.” It can be seen that the attitude is not a stand-alone concept, as it is directly connected and dependant on other concepts.

2.9.1 Knowledge and Attitude of Teacher towards Sustainability Chemistry.

A knowledge can be in the form of oral and written. Knowledge can be grouped into explicit knowledge and tacit knowledge. While the former describes “knowing about”, the later describes “knowing how” based on experience which influence behavior. Through knowledge, it can create awareness or concern that will shape a positive attitude towards green chemistry (Palilonis, 2012).

The assumption is that ‘‘if people become more knowledge about the environment and its associated issues, they will in turn become more motivated to act towards the environment in more responsible ways”(Fahlquist, 2008).Studies have shown that teachers knowledge of sustainability issues were not well develop and seems to have knowledge when asked about sustainability about green chemistry, however, their ideas are allowed and they were unable to relate that knowledge into practices in classroom (Riess&Mischo, 2010; Burmeiter&Eiks, 2015).

Tekzok *et al*., (2010) aimed to determined level of chemistry teachers' knowledge and their attitude on Green Chemistry. The teacher strongly emphasized a concern for the environment development of awareness and sensitivity to the total environment and gaining social values to protect the natural resource through teaching concepts and new practice such as green chemistry. Ernesto (2004) conducted a study to evaluate the awareness, knowledge and attitude of teacher. This study found statistically significant differences among groups regarding the level of awareness, knowledge, attitude towards green chemistry. His study revealed a negative relationship between awareness and attitude.

Some studies (Ries and Wischo, 2010; Burmeister and Eilks, 2013) indicated teacher's knowledge of green chemistry issue were not well developed. Many teachers seemed knowledgeable when asked about sustainability and green chemistry. However, teachers' ideas were shallow and they were unable to relate that knowledge into practice in the classroom. It was also revealed that teacher lack the skill and knowledge to implement green chemistry (Garner and Eilk,2015; Makoni,2013; Burmeister, Rauch and Eilks, 2012). Enhancing knowledge would sad to more awareness which would also result in more eco- friendly practices and behaviours.

2.10 Gender and Green Chemistry

Zelency, Chua and Aldrick(2000) conducted a literature review on gender difference in environmental altitudes and green chemistry. They opined that women have stronger according to the tripartite classification presented by Stern and Dietz (1994) women expressed greater concerns for the biosphere, other human and their own well being.

Tuncer (2008) conducted a similar study aimed at investigating university students' perception of green chemistry the result revealed that while there was a statistically significant mean difference between boy and girls with respect to perceptions on green chemistry.

Kaur (2012) conducted a study to give information about the level of environment awareness of students in India. The findings showed that the students possess fairly good level of awareness regarding environment degradation and green chemistry the study also revealed that no gap exist when distributed gender wise. Pillai (2012) disagree, with Kaur, (2012) when he conducted a study on environment awareness on pre-service teachers in India too. He recorded a statiscally significance awareness of male and female students.

Also, Sivakumar (2012) investigated the environment awareness of student related to their gender, caste and type of school (government/private). The study was conducted in Karnatata. The revealed that; gender and location have interaction effect on awareness. This result also corresponded which that of Kumar and Malti (2011) which recorded an influence of types school, gender on the level of awareness on green chemistry.

However, the findings of skivakumar and Vamadevappa (2011) revealed that;

1. Gender does not play any role on environment altitude
2. The student who belong to urban background are comparatively better in terms of their environmental altitude
3. The student to private schools have more favourable environmental altitude than the students of government schools.

Aminrad (2010) also, noticed a significant difference between group of teacher based on gender. The study concluded that increase on age and level of education would improve the level of awareness and attitude.

2.11 Theoretical Framework

This section dived into the various theories of attitude and awareness.

2.11.1 The Tri component viewpoint of Attitude

This was represented by Krech, Crutchfield & Ballachey (1962). It involves feelings and emotions towards the three distinct components or dimensions of attitude which include:

The COGNITIVE component – which is a set of beliefs about attributes of the attitudes' object;

The AFFECTIVE component – which includes positive and negative feelings about the object; and

The BEHAVIOURAL component – which pertains to the way people act towards the object.

This viewpoint was popular in 1960s but was criticised for a number of weaknesses such as the fact that some people may tend to develop their attitudes on the basis of their feelings while others may choose to rely mostly on their beliefs. (Huskinson & Haddock, 2004).

2.11.2 The Separate Entities viewpoint, which was strongly advocated by Fishbein and Ajzen (1995) regards the above-cited components as being distinct separate entities. The term 'attitude' is solely reserved to the affective component while behaviour and cognition are considered as 'determinants' rather than components of attitude and are to be assessed separately. One of the drawbacks of this approach is the classification of evaluative beliefs (an intermediate category) which overlap significantly with affective responses (liking or disliking) and hence cannot be treated separately from attitudes (Oskamp & Schultz, 2005).

2.11.3 The Latent Process viewpoint, which is associated with DeFleur and Westie (1963) considers attitudes as a latent (or hidden / invisible) variable that can help explain certain observable stimulus events and behaviours. According to this perspective, the stimulus event (e.g.green chemistry practice) will trigger latent processes (which could be cognitive, affective or behavioural) within the individual, which result in the expression of an attitude summarising the information of these hidden processes (Eagly & Chaiken, 2005; Fabrigar, MacDonald & Wegener, 2005; Oskamp & Schultz, 2005).

This viewpoint of attitudes which formed the basis of the theoretical framework of analysis of attitude data in this study, has a number of advantages over the other two views. In fact, unlike the 'separate entities' viewpoint, this perspective does not equate attitude exclusively with the 'affective' or 'emotional' responses, thereby excluding completely the cognitive and behavioural dimensions of attitudes. Besides this, in contrast with the 'tricomponent viewpoint', the latent process point of view does not stress that the three components of attitudes must necessarily be congruent. An attitude may arise from one or a combination of processes, i.e. affective, cognitive and behavioural (Zanna & Rempel, 1988) and may generate one or more of the corresponding types of observable responses (Breckler, 1984).

2.11.4 Environmental Awareness from the Aspect of Pragmatism

It has been agreed by many philosophers that education and awareness towards environmental protection and conservation require knowledge, understanding, and the change of attitude by each individual. Within the context of education, it is the process to solve the problem which is need to be implemented among individuals since infancy, as it able to provide people with the technique

in dealing the difficulty in life(through green chemistry practices). This element is supported by the idea of western philosophy, which is the pragmatism movement. The philosophers believe that an individual's role in taking care the environmental is different based on the development of age (Mak Soon Sang, 2000). This philosophy presumes that knowledge can be acquired from the relation between human and nature, as both elements are interconnected (Abd. Rahman Aroff and Zakaria Kasa, 1987). Thus, within the context of education, the implementation of the environmental values(green chemistry) among teachers can be carried out by giving teachers the experience through the basic activities such as working together to remain the healthy environment and expose teachers with the impact of environmental pollutions. For instance, there are several ideology and philosophy that has been introduced, such as the programme of "green chemistry" that introduced by the chemist in order to reduce the effect of environmental damage (Zaini Ujang, 2008). Through these activities, it shows that the students are not only trained from the aspect of intellect and physical, but also from the element of spiritual and emotion through courage and appreciation towards the programmes.

On the other hand, based on realism of epistemology, knowledge is a process to discover a thing and new phenomenon, and the process should relate with the physical object that exist within the actual life, and be able to examine through human sense. According to this epistemology, the accurate knowledge is the knowledge that relate with the physical nature. This epistemology also focuses on the development of students' potency, as well as encourages students towards rational thought and activity within the realm of education. For instance, the Science's teacher can provide the knowledge, and at the same time ask the students to think on the greatest of God through the appreciation towards the nature. The students should be trained and guided to look at the creation of God which able to amaze and create the feeling of fear towards God within

themselves. Thus, to produce a firm and balanced student, the students should gain a high awareness towards the surrounding. For instance, the student that studies Science (chemistry) should concern on the elements of the nature in making their hypothesis by using the appropriate approach.

2.11.5 Environmental Awareness from the Aspect of Metaphysic

On the other hand, the aspect of environmental awareness is also discussed from the view of metaphysic. This branch of philosophy focused towards the elements of belief/religion and the emergence of this universe which need to be emphasized within the education, in producing the balanced individual from the aspects of emotion, physical, intellect and spiritual. Based on this aspect of philosophy, there are several concepts that need to be focused within the life of students. Among of them are; the important of religion and belief within the education system, to produce a firm and balanced individual, the ecological protection, the reality of the creation of human and nature, as well as the awareness within the individual itself. Thus, it can be said that the surrounding and environment play the significance role within the realm of education. It is because, the element of nature and human are closely related.

For instance, the environmental awareness among the students can be viewed and related with the belief of Islam. This religion is not only focusing on the aspect of intellect, but also the need of mind and spiritual within human self. It defines that the process of education should be included with the aspect of intellect, physical, emotion, and the development of manner, bravery, as well as the sense of respectability. It states that the belief and moral cannot be separated as both aspects are based on Quran, which include the quality of moral and human behavior. For instance, the axiology of Islam states that the moralistic individual is the balanced individual

from the aspect of manner and act, such as the awareness towards environment as the person is able to manage his emotion and action from spoiling the nature.

Besides, according to the metaphysic of Islam, this universe is belonging to Allah SWT, not human. Thus, it is very important to maintain the ecological stability. Human should realize that they are appointed by Allah to become a *caliph* or leader in flourishing this earth, as they are provided with mind and potency to manage this world (Saidul Amin Usman, 2000). This accountability towards human has been stated in Quran, Surah An-Nahl Ayat 10.

Based on this *Surah*, it is clearly stated that this universe is entrusted towards human to be entirely benefited. As a human or individual who has been entrusted to inhabit and concern this world, humans have the responsibility to make sure this expectation is well used. It is because the moral individual would consider regarding the protection and nurturance of the environment (Zaini Ujang, 2008). Besides, Islamic Philosophy has been implemented within the National Philosophy of Education in order to produce the responsible, moralistic, and trustworthy individual (Mohd Salleh Lebar, 2002).

In addition, the highly environmental awareness among students provides opportunity to learn on how to nurture this nature and exploitation of the sources. This will prepare the students to become the responsible individual that able to contribute towards the harmonious society and nation.

2.11.6 Environmental Awareness from the Aspect of Axiology

Furthermore, the aspect of axiology focuses towards the moral of students. Thus, consistent with the effort to produce the balanced individual from the aspect of intellectual, physical, emotional and spiritual, the awareness towards environment should be implemented among the students. It

is because, from the aspect of axiology the theory of value is closely related with the element of belief and faith. As the branch of axiology is divided in to two factors which are moral and esthetic, thus, the awareness towards environment should fulfill both aspects. In producing the ethical students, the students should obey the rule of society. If the rule concern on the awareness towards environment, the students will directly concern on the environment and produce the society that aware towards the surrounding. In addition, from the aspect of esthetic the students will reinforce their appreciation towards the beauty of nature and this will encourage them towards environmental awareness.

Furthermore, from the context of The National Philosophy of Education, the aspect of axiology plays the important role to produce the moralistic and responsible students towards the surrounding. Hence, the level of environmental awareness among students is very important in fulfilling the aspiration of National Philosophy of Education. It is because, the good and healthy environment is able to encourage and develop students' mind towards the learning process.

2.11.7 Environmental Awareness from the Aspect of Idealism

Besides, from the view of Western education philosophy which is Idealism, the element of moral is defined as universal and general concept and exists within the spiritual and mental. Thus, to fulfill the aspect of moral, environment is very important in producing the balanced individual from the aspect of spiritual and emotion. This is because students need to be revealed with the important of the cleanliness and the beauty of nature. The value towards the significance of environment is very important to be implemented among the students, which is able to represent the balanced and harmonious element.

2.12 Empirical Framework

Nurbaity, Yuli Rahmawati, and Achmad Ridwan (2010) in their study‘‘Integration Green Chemistry Approach in Teacher Education Program for Developing Awareness of Green Chemistry’’. The research was conducted for pre-service (undergraduate) and in-service teachers in chemistry classroom. A qualitative approach was employed in this research and involved interviews, observations and the use of reflective journals. The results of the study showed that the pre-service and in-service teachers become aware of environmental problems and to think about the future and current role as teachers. They started to reflect on the values and principles of green chemistry that can be implemented in chemistry classrooms. The study also found that the soft skills of collaboration with others, communication and argumentation skills, then creative and critical thinking skills were developed.

Also, Biswajit Sahooand Dr. Satyajit Kar(2016) worked on knowledge about green chemistry of tribal and non- tribal teachers. Descriptive Research Methodology with survey techniques was used in the study. The researcher used 240 samples for this study from Paschim Medinipur districts of West Bengal. A self-made questionnaire was used to collect data. Collected data was analyzed with suitable statistical techniques like t- test, Descriptive statistics, through MS-Excel 2007.The result revealed that there are some difference of knowledge about green chemistry with respect to gender, location of the schools and also to the combined of gender-location of the schools.

Alake Ese Monica(2017) in her work “Green chemistry: Senior secondary teacher’s awareness and practice in southern Nigera”. The level of awareness, understanding and practice of green chemistry was investigated among senior school chemistry teachers in Southern Nigeria. 30

senior secondary school chemistry teachers from 12 secondary schools in the region constituted the sample. Data was collected through a 25 item questionnaire (CSQ). Percentages and t-test was used to analyze data collected. The study revealed that 40% of senior secondary school teachers have knowledge and practice green chemistry in Southern Nigeria. 60% of the teachers do not know the meaning and do not support their environment. The results of findings revealed very low understanding and practice of green chemistry by teachers. Teachers in urban locations had better practice of green chemistry. Recommendations suggested include more benign topics in senior school chemistry curriculum.

Taha H, Suppiah V, Khoo Y , Yahaya A, Lee T and Muhamad Damanhuri M(2010) studied the Impact of green chemistry experiments on teachers knowledge, awareness and practices. The study investigated the impact of student-initiated green chemistry experiments on students' level of knowledge, awareness and practices of environmental sustainability; and students' achievement in the topic of rate of reaction. The quasi-experimental study involved 46 secondary school students with 23 students each in control and treatment groups. A set of questionnaire and a set of test were employed in the study; and data was analysed using descriptive and inferential statistical techniques. Results showed significant difference in awareness, between the groups; but a weak insignificant correlation between knowledge and awareness on green chemistry. It was also indicated awareness on green chemistry as a strong significant predictor for practice. However, results revealed no significant difference in the achievement between students undergoing traditional chemistry experiments and the green chemistry experiments. Nevertheless, students participated in designing green chemistry experiments have higher level of awareness and practice of environmental sustainability. This study recommends that teachers should

empower students with suitable mechanisms to address sustainable environment issues in classroom or laboratory instruction to promote sustainable practices among them.

Zarrintaj Aminrad, Sharifah Zarina, Binti Sayed Zakariya, Abdul Samad Hadi and Mahyar Sakari(2009) also studied theRelationship between Awareness, Knowledge and Attitude towards Green Chemistry Education among Secondary School Teachers in Malaysia.The study was conducted to identify the relationship between environmental awareness, knowledge and attitude among secondary school teachers. The survey was conducted on 70 respondents in Kajang city, Selangor, Malaysia. An instrument which included (48 questions) was employed to investigate the relationship between awareness, knowledge and attitude. The results of Person Correlation showed a significant but weak relationship between awareness and knowledge on green chemistry while there was high relationship observed between awareness and attitudes among respondents. Moreover, the statistical test showed a negligible relationship between knowledge and attitude among teachers about environment. The study concluded that a high level of awareness and knowledge plus positive attitude of teachers may come have been achieved from the background, media, private reading and school curriculums regarding the environment that increases the environmental view among teachers as well as overall in the society. The study recommended that green chemistry as a subject necessarily might be considered as an independent syllabus in Malaysian education system.

Arba'at Hassan, Norshariani Abd Rahman & Sharifah Intan Sharina Syed Abdullah (2011) did a similar work on The level of Green Chemistry Knowledge, Awareness, Attitude and Practices among UKM teachers.The study was conducted at Universiti Kebangsaan Malaysia (UKM) to

reveal knowledge, awareness, attitudes and practices towards environment among teachers. The survey employed a quantitative approach using questionnaires involving 20 respondents (n=20). Research findings indicated that teachers had the knowledge, awareness and attitudes towards environment at a high level but the practices of green chemistry were at a moderate level. Based on gender, there were no significant differences in terms of knowledge, awareness and practices towards green chemistry. However, there were significant differences in terms of attitudes which female students had higher attitude to environment as compared to male students. The Pure Science teachers had the highest level of awareness as compared to students from other disciplines. In terms of attitudes and practices, there was no significant difference between male and female teachers. There was a significant relationship between knowledge, awareness and attitudes to the practices of environment. The suggestion made was that green chemistry Education in UKM should be more "*hands-on*" to form more consistent behavior in protecting the environment.

Arba'at Hassan, Tajul Arifiin Noordin and Suriati Sulaiman (2008) conducted a study in Malaysia titled ‘‘The level of environmental awareness in the concept of green chemistry among secondary school teachers”. The survey was conducted on 80 respondents (n=80) from urban area in the district of Hulu Langat, Selangor (Bandar Baru Bangi and Mukim Hulu Langat). Dependents the level of environmental awareness in the concept of green chemistry and practices, attitudes and moral sustainability. Independent variables on the demographic factors were gender, types of subject streaming, and school. Research instrument used was the questionnaire, using Likert scale. Methods of analyzing data were descriptive, correlation using SPSS software ver. 11.5. Research outcomes showed that secondary school teachers had “high environmental awareness in the concept of green chemistry. The t-test analysis showed significant differences at level of 95%

($p<0.05$). It indicated that the level of environmental awareness for the (i) female teachers were higher than the male teachers, (ii) urban school teachers were "higher" than suburban school teachers. The Pearson correlation showed that there was positive but weak tween the level of environmental awareness in the concept of green chemistry and the practices, attitudes towards green chemistry.

The study of Mageswary Karpudewan, Zurida Ismail and Norita Mohamed(2000) discusses the findings from a survey conducted to investigate the level of awareness and understanding of traditional environmental concepts and green chemistry concepts among teachers. The survey involved 40 teachers. The teachers were requested to complete a set of 20-item questionnaire on environmental knowledge. Awareness and understanding of concepts central to Green Chemistry is particularly significant for the teachers who are required to educate and promote education for sustainable development. Results of the study showed that the teachers have a low level of awareness and understanding of concepts central to green chemistry compare to traditional environmental concepts. Recognising the importance of green chemistry knowledge in leading sustainable lifestyle, the findings emphasized the need to impart sustainable development knowledge through teaching and learning process.

Army Auliah, Muharram and Mulyadi(2018) also conducted a study titiled ‘‘Indonesian Teachers' perceptions on Green chemistryprinciples:a case study of a chemical analyst vocational school"The study aimed at describing the teachers‘perception of Green Chemistry. The description of Green Chemistry is based on the teachers' perception of a Green Chemistry paradigm and how to integrate this perception into the chemistry learning process for students. The perception and integration of Green Chemistry to achieve sustainable development in the field of chemistry needs to be promoted, especially among educators for spreading to students.

Data were collected by distributing questionnaires to 35 teachers in a Chemical Analyst Vocational School, Makassar, Indonesia. The questionnaire was based on the indicators related to the principles of Green Chemistry including prevention, economic atom, chemical synthesis safe, designing safer chemicals, solvents and compounds safe aides, design for energy efficiency, use of raw materials renewable, stages reduction reactions, use of catalysis, material design decomposition, instantaneous analysis for pollution prevention and chemical which are naturally more secure to prevent accidents. Data were analyzed descriptively to determine the percentage of teachers' perceptions of green chemistry in learning. The results showed that, in general, the majority (97.14%) of teachers at this Indonesian school reported knowledge of Green Chemistry but only 32.30 % were aware of the concept of Green Chemistry. Furthermore, 47.42% of the teachers think that green chemistry does not need to be put into learning curriculum and 31.38% believe need to be included in the learning process. These finding demonstrate that the concept of Green Chemistry has not been socialized among teachers of Chemical Analyst Vocational School of Makassar. For this reason, there is a need for developing a learning model in chemistry teaching that responds to our vision for a sustainable future.

Gaye Teksoz, Elvan Sahin and Hamide Ertepinar(2001) in the study ‘‘A new vision for chemistry education: pre-service chemistry teachers environmental literacy and their perceptions on environmental education’’. The study aimed to determine level of pre-service chemistry teachers environmental literacy and their perceptions on environmental education. The study was realized during the fall semester of 2006-2007 academic year with the participation of 60 students enrolled in five-year chemistry teacher education program. The data collected by administration of Environmental Literacy Test and Environmental Education Perception Survey were analyzed by descriptive statistics and content analysis. The pre-service chemistry teachers strongly

emphasized promotion of feelings of concern for the environment, development of awareness and sensitivity to the total environment, and gaining social values to protect the natural resources through teaching on environmental issues. The results also revealed that these participants had favorable attitudes toward the environment and feelings of personal responsibility to create a better environment. However, pre-service chemistry teachers did not have a sound understanding of environmental issues. Although the participants were lack of necessary subject matter knowledge, they were willing to integrate environmental issues into their teaching practice. Thus, chemistry education students are potential candidates as environmental educators and their education programs may be strengthened in this respect.

Ngozi-Olehi, Achinihu I., Okenyi B.,and Ibe C.(2017) investigated the gap between chemical education and drive to green chemistry as perceived by lecturers of chemistry in Imo State. The perception of chemistry lecturers towards the structured curriculum presently in use in the higher institutions and its relationship to green chemistry was surveyed. A total population of one hundred and five lecturers from six tertiary institutions in Imo State which also was the sample size were used for the study. Research questions were used to obtain data, validated using the Chi Square statistical tool. The Chi-square calculated result showed $X_C^2 = 262.56$ which was greater than the tabulated value of 5.99. The results therefore suggested that chemistry lecturers in Imo State believe there is a gap between the present day chemistry curriculum and green chemistry ideas and principles.

2.10 Chapter Summary

Green chemistry is a relatively new area of chemistry that aims to prevent pollution by focusing on the molecular level to design safer non-toxic and non-hazardous chemicals and chemical processes. It is also known as sustainable chemistry as it protects human health and the

environment and is also economically viable. This new science is based on a set of guidelines known as “The Twelve Principles of Green Chemistry”. These principles serve as a framework for chemists to evaluate the ‘greenness’ or sustainability of chemical products and reactions and are regarded as the rules of the game for the adoption of green chemistry by the chemical industry. The recent history of green chemistry shows that it was born in the USA in the early 1990s as a reaction by chemists to address environmental problems created in the twentieth century by the chemical industry but also to counteract the mounting legislation to control pollution.

The parallel evolution of the concepts of green chemistry and sustainable development earned the attention of educational fora and institutions, and educators started promoting them in various levels of education. Green chemistry started being taught in universities in the 1990s but was later adapted to younger audiences and introduced in the curriculum of secondary and post-secondary schools. Literature suggests also that teaching green chemistry to young students enables them to relate better basic chemistry concepts to everyday lives and may even attract bright students to chemistry careers. However different sources indicate that a number of potential difficulties may hinder the introduction of green chemistry in schools. These include an already overburdened curriculum, resistance from teachers, lack of adequate educational resources and different forms of skepticism.

Considering that students in secondary schools are already familiar with the concepts of sustainable development, it appears to be logical to present green chemistry in schools as the real centre of sustainability. Such move would possibly help improve the public perception of chemistry and attract more students to study the subject. Integrating green chemistry in the school

chemistry curriculum would also help the green chemistry message to reach a wider audience and prepare future chemists and scientists to face better the challenges of a future sustainable world.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter discusses the methodology that was used in conducting this study. It describes the research design and study population. It also highlights the study design that was employed. Under this category the chapter describes the sample size and sampling methods. Data analysis procedures used, instrument for data collection, validation and reliability of the instrument.

3.2 Research Design

A research design is a plan or blue print, which specifies how data relating to a given problem should be collected and analysed. It provides a procedure for the conduct of any given investigation (Nworgu 1967).

The type of research design adopted for this study is the descriptive survey, which involves eliciting information from the respondents. According to Ali 2006, when a survey centres on descriptive variables in relation to a given population, the descriptive survey is the most appropriate. The descriptive research design is able to ascertain, the level of awareness and attitude towards implementation of green chemistry practice and the possible influence of gender on their practice of green chemistry.

3.3 Study Population

The population consist of all public Senior Secondary School Chemistry Teachers in Minna metropolis Niger State. Minna metropolis is made up of two Local Government Areas; Bosso Local Government and Chanchaga Local Government Areas. Bosso have a total of thirteen (13)

public secondary schools while Chanchaga have total of nine (10) public secondary school. Making a total of twenty-three (23) public secondary schools. The study population was fifty-one(51)teachers from all the public Senior Secondary School.

The list of all public secondary school in Minna metropolis was acquired from the Niger State Ministry of Education. The list of the schools and the respective population of chemistry teachers is presented in appendix II.

For a school to be part of the study, the school must;

i. have a good and standard chemistry laboratory
ii. not be a special school
iii. not be an art or vocational school

Based on these criteria, the schools selected and the respective chemistry teachers' population is summarized in appendix iii.

3.3 Sample and Sampling Technique

A Purposeful or Judgmental Sampling technique was used to select the schools for the study. This is a situation where the characteristics or special feature will determine if a school will be part of the study or not. A total of nineteen (19) schools were selected from the population. A representative sample of 50 chemistry teachers was selected from the sampled schools.

3.4 Instrument for Data collection

The instrument for data collection was the Green Chemistry Questionnaire(GCQ) which was developed by the researcher to determine the level of awareness and attitude towards implementation of green chemistry. It included 34 closed-ended questions covering various aspects of green chemistry at global and local levels. It is believed that closed-ended questions probably limit the responses to the topics.

The GCQ used a four point Likert - type response scale and agree/disagree response in sections B and C of four rates of "1=Strongly Disagree"(SD), "2=Disagree"(D), "3=Agree" (A) and "4=Strongly Agree"(SA).In section D, the four rates used are 1=Never, 2= Seldom, 3=Often and 4= Very Often.

The GCQ has a set of question designed to answer the research questions and hypotheses. The content of this questionnaire covered four parts, namely: Part A - an item to find out personal information of participants in terms of demographics; Part B - an item to access the level of awareness and knowledge of green chemistry; Part C - to study the attitude towards green chemistry implementation; and Part D - an item to assess the levels of implementation of green chemistry in classrooms and school laboratories. The teachers were required to tick against the option close to their opinion.

3.5Validation of the instrument

Validity refers to the extent to which an instrument measures what it was supposed to measure (Mugenda and Mugenda, 2003). The GCQ was evaluated for face and content validity. The questionnaire was read and examined to evaluate the clarity of items taking into consideration of the awareness of green chemistry by the project supervisor.

The GCQ was then subjected to the judgment of two experts in chemistry education who had proven expertise in their respective fields of research to determine its content and contrast validity. The experts' criticism reduced the item of the questionnaire from an initial item of 34 to 28

3.6 Pilot Test

The GCQ was pilot tested in Niger State School for Special Education Minna, Government Vocational Centre and Women Day College. These schools were part of the population but were not part of the sample population. A total number of twenty (10) chemistry teachers were used for this purpose. This was done with the sole purpose of detecting any weakness and finding out whether the questionnaire is clear to the respondents. During the exercise, unclear and ambiguous questions were reframed and others scrapped. This was instrumental in revealing if the anticipated analytical techniques were appropriate. The result obtained from the pilot study was then used to determine the reliability coefficient of the GCQ.

3.7 Reliability of the Instrument

Reliability is a measure of degree to which research instrument yields consistent results or data after repeated trials. It is verified by the consistency of the observation of an outcome. To test the reliability, the researcher used split half technique which involved splitting the test into two, the first odd-numbered, the other even numbered, both the even and odd items are equally matched on content and difficulty index, but not the same test. The even-numbered test item was administered to the group as well as the odd-numbered test items to the same group. The two half tests were scored independently of the other to obtain two sets of scores.

The scores of the two halves were correlated using the Spearman Rank Order Correlation formula to obtained the reliability coefficient of the half-tests. Spearman-Brown Step-up (prophecy) Formula was then used to estimate the reliability of the whole test which yielded a reliability co-efficient of 0.87.

3. 8 Procedure for data collection

The questionnaires are being administered to the students, directly by the researcher and are also being retrieved directly from the students, by the researcher for data analysis.

The GCQ was administered to all the sampled teachers. The questionnaire sheets were given directly to the teacher participants who completed the survey individually at their schools. On average, participants completed the survey in 20 minutes.

3.8.1 Return Rate of the Questionnaire

A total of forty(45) questionnaires were given. A 100% rate of return was recorded as all the teachers that participated in the exercise filled the GCQ properly and returned the GCQ.

3.9Data Analysis

Qualitative and quantitative data techniques were used in analysis of data. This was used to analyze quantitative data to generate frequencies, means, percentages and standard deviations.

3.9.1Decision Rule

The Likert scale has four levels or categories namely: strongly agree; (SA): Agree (A); Disagree (DA); strongly disagree (SD). Each level is assigned a number ranging from 4 (SA) to 1 (SD).
The researcher computed the mean as thus: 4+3+2+1/4= 2.5
With 2.5 as the computed mean, it means that any item or variable with a mean 2.5 or above is regarded as positive while all others with a mean below 2.5 are regarded as negative (i.e. not a factor as perceived by the respondents). This was used to answer all the questions.

For the hypotheses, students' t-test was used to analysed and test for significant difference.

Reject the hypotheses, if the computed value of t-test exceeds the table value. If otherwise, the hypotheses are not rejected.

3.10 Logistical and Ethical Consideration

In order to conduct the research, a letter of request to conduct the research was done to all Principals of the selected schools. The letter was aimed at introducing the researcher, seeking authorization and assistance. This helped reduce suspicion and as result school heads gave maximum support to the study. The respondents were also assured of confidentiality and anonymity of the information they would give.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION

4.1Introduction

This chapter deals with the presentation of results under the following sub- headings, presentation of results and discussion of major findings. Research questions raised were answered using mean and standard deviation while students' t-test was used to test the null hypotheses at 0.05 level of significance

4.2 Demographic data

A total of 50 questionnaires were filled and returned. From the questionnaires returned, 31 were male teachers consisting 62% of the total respondents while 19 were female teachers consisting 38% of the study population. From the results obtained in Table 4.1, it was also found out that there were more male respondents compared to female respondents.

Table 4.1 Gender of the respondents

GENDER	N	%
MALE	31	62
FEMALE	19	38
TOTAL	**50**	**100**

4.3 Answering Research Question

Research Question 1: What is the level of awareness of green chemistry among chemistry teachers in public schools in Minna Metropolis?

4.2: Analysis of response as regards the awarenessof green chemistry

S/N	Items	SA	A	D	SD	total	mean	S.D	Remark
1	I have an understanding of what is meant by environmental chemistry	**28**	**20**	**2**	**0**	**50**	**3.53**	**0.57**	**Accept**
2	I have an understanding of what is meant by 'green chemistry'	**1**	**4**	**35**	**10**	**50**	**1.52**	**0.57**	**Reject**
3	Environmental chemistry and green chemistry are pretty much the same thing	**11**	**18**	**19**	**5**	**50**	**2.52**	**0.87**	**Accept**
4	Green chemistry is just a more catchy term for environmental chemistry	**15**	**20**	**10**	**7**	**50**	**2.58**	**0.99**	**Accept**
5	Green chemistry is a new dimension of environmental chemistry	**7**	**29**	**20**	**3**	**50**	**2.63**	**0.67**	**Accept**
6	Green chemistry tries to prevent pollution before it starts	**3**	**7**	**38**	**2**	**50**	**2.22**	**0.57**	**Reject**
7	Green Chemistry tries to protect the environment by identifying possible sources of pollution and treating pollutant, but it should be doing more than that	**6**	**20**	**19**	**5**	**50**	**2.84**	**0.88**	**Accept**
8	Green chemistry helps us change the wrong perception of people that chemistry is the main cause of environmental hazards	**0**	**25**	**25**	**0**	**50**	**2.50**	**0.50**	**Accept**
9	I am aware of the twelve principles of Green chemistry	**0**	**3**	**36**	**11**	**50**	**1.84**	**0.50**	**Reject**
10	Green chemistry can help achieve sustainability	**0**	**21**	**23**	**6**	**50**	**2.30**	**0.67**	**Reject**

Grand Mean = 2.44

From Table 4.2 it is seen that the teachers havean understanding of environmental chemistry but show no understanding of green chemistry(mean = 1.52). The table also revealed that the teachers agree that green chemistry and environmental chemistry are thesame; this was captured in items 3, 4 and 5 in Table 4.2. The teachers arealso aware that green chemistry can change the bad

perception of chemistry but they are not aware that it can help achieve sustainability. The data presented also shows that the teachers are not aware of the twelve principle of green chemistry.

Research Question 2: What is the level of implementation of Green Chemistry in public secondary school in Minna Metropolis?

Table 4.3: Analysis of response as regards the implementation of green chemistry

S/N	Items	Very often	Often	Seldom	Never	Total	Mean	S.D	Remark
1	In my teaching I relatechemistry to everyday life	**2**	**23**	**25**	**0**	**50**	**2.54**	**0.57**	**Accept**
2	I Include green chemistry concepts in the classroom and laboratory work	**1**	**5**	**14**	**30**	**50**	**1.54**	**0.75**	**Reject**
3	I Perform reaction involving the release of gas in a fume cupboard	**0**	**0**	**10**	**40**	**50**	**1.20**	**0.40**	**Reject**
4	I Close fume hoods when not in use to reduce energy use	**0**	**0**	**10**	**40**	**50**	**1.20**	**0.40**	**Reject**
5	I Neutralize base or acid to pH 7 before pouring down the drain	**0**	**0**	**2**	**48**	**50**	**1.04**	**0.20**	**Reject**
6	I use green solvent such as green solvents like ionic liquids, supercritical CO2 fluid instead of alcohol or benzene	**0**	**0**	**0**	**50**	**50**	**1.00**	**0.00**	**Reject**
7	I run experiments on the microscale to reduce waste	**0**	**0**	**11**	**39**	**50**	**1.22**	**0.41**	**Reject**
8	Recycle pipette tip boxes, and water purification cartridges	**0**	**0**	**0**	**50**	**50**	**1.00**	**0.00**	**Reject**

Grand mean=1.49

From table 4.3,it shows that the teachers relate the teaching of chemistry to everyday life (mean = 2.54) but have a poor practice of green chemistry during laboratory and class work teaching (this is revealed in items 2-8 in table 4.3

Research Question 3: What is the attitude of teachers towards teaching of green chemistry in Minna Metropolis.

Table 4.4: Analysis of teachers' response towards attitude of green chemistry

S/N	Items	SA	A	D	SD	n	mean	S.D	Remark
1	I think the ways of teaching chemistry must change and include green chemistry so as to appeal more to students	**7**	**25**	**15**	**3**	**50**	**2.72**	**0.78**	**Accept**
2	I will like to include concepts of green chemistry in my teaching	**5**	**40**	**5**	**0**	**50**	**3.00**	**0.45**	**Accept**
3	Students are generally more interested in learning about green chemistry than about more traditional topic	**0**	**25**	**25**	**0**	**50**	**2.50**	**0.50**	**Accept**
4	I think green chemistry principles are too expensive and has no place in the Nigerian chemistry curriculum	**3**	**25**	**17**	**5**	**50**	**2.52**	**0.75**	**Accept**
5	I think it is more important to study the foundations of chemistry than to introduce green chemistry in secondary schools	**9**	**23**	**10**	**8**	**50**	**2.66**	**0.95**	**Accept**
6	I think the best way to introduce green chemistry to O-level student is by studying it as a separate topic	**2**	**39**	**5**	**4**	**50**	**2.78**	**1.64**	**Accept**
7	I think the principles of green chemistry are easy to apply	**5**	**10**	**30**	**5**	**50**	**1.50**	**1.11**	**Reject**
8	There is no need introducing green chemistry because chemistry cannot be rendered green	**1**	**25**	**15**	**9**	**50**	**2.36**	**0.79**	**Reject**
9	The principles of green chemistry are hard to apply	**5**	**30**	**10**	**5**	**50**	**2.70**	**0.78**	**Accept**
10	I think it is useless studying green chemistry since there are no suitable textbooks at the secondary level	**0**	**25**	**25**	**0**	**50**	**2.50**	**0.50**	**Accept**

Grand mean = 2.57

Table 4.4 shows that teachers agree that the curriculum need to change and include green chemistry concept and practise and they also show a positive attitude towards including concepts of green chemistry in their teaching. The teachers also believe that green chemistry principles are too expensive and hard to apply.

Research Question 4: What is the effect of gender on the awareness and attitude of green chemistry practices?

Table 4.5: Analysis of awareness and attitude of green chemistry in respect to gender

GENDER	AWARENESS			ATTITUDE		
	N	MEAN	SD	N	MEAN	SD
MALE	31	2.42	0.31	31	2.51	1.01
FEMALE	31	2.44	0.27	19	2.63	0.69

From table 4.5.1 it is seen that both the male and female teachers have negative awareness of green chemistry with the female teachers scoring a higher mean of 2.39 than the male teachers scoring a mean of 2.41showing a difference in mean of 0.02. In terms of attitude, the female teachers also have a higher mean of 2.51 than the male teachers showing a mean score of 2.51.

4.4 Testing Hypotheses

Hypothesis 1: There is no significant difference in the awareness of green chemistry among male and female chemistry teachers

Table 4.6: mean, standard deviation and t-test analysis of male and female score relating to awareness

Gender	N	X	s.d	df	t_{val}	P value	Sig
Male	31	2.42	0.31				
				48	0.23	0.8174	NS
Female	19	2.44	0.27				

***NS= Not significant**

Table 4.6: shows the mean, standard deviation and t-test of both male and female teachers in respect to awareness. The t-value calculated 0.23 with p value of 0.8174 shows that there is no significant different. This means that the first null hypothesis of no significant difference in the level of awareness between male and female teachers is accepted.

Testing Hypothesis 2. There is no significant difference in the attitude towards green chemistry practises among male and female chemistry teachers

Table 4.7: mean, standard deviation and t-test analysis of male and female score relating to attitude

Gender	N	X	s.d	df	t_{val}	P value	Sig
Male	31	2.51	1.01				
				48	0.43	0.6687	NS
Female	19	2.63	0.86				

*NS= Not Significant

Also, Table 4.7 shows the mean, standard deviation and t-test of both male and female teachers in respect to attitude. The t-value calculated 0.43 and p value of 0.6687 indicated that there is no significant difference. This means that the second null hypothesis of no significant difference in the level of attitude between male and female teachers is accepted.

Discussion

Van-Ejick (2007) emphasized that the integration of green chemistry in the curriculum contributes to the general aims of science education, bearing in mind that science education is an important element in the development of scientific literacy. Green Chemistry as earlier stated evolved from academic research and has become accepted and supported by academia, industry, and government of most developed countries.

During the study, respondents were asked whether they were aware of Green Chemistry. From the results indicated in the Table 4.2, it was realized thatthe findings of this study suggest that

teachers in secondary school are well aware of environmental chemistry. However, it was also observed that majority of teachers have no or slight idea of Green Chemistry. Given that environmental issues are emergent and dynamic.

The findings of this study implies that teachers in Minna Secondary school are not and may not be well prepared in the future to address current and emerging environmental issues. Majority of teachers in Minna Metropolis were not aware of green chemistry with most of the teachers disagreeing (70%) and having a mean score of 1.52. These findings are evidence that chemistry teachers in Minna Secondary schools have little or no awareness of new and emerging concepts relating to environmental issues and problems. These findings agree with the results of the study done in Sabah in Malaysia that concluded that though the level of environmental awareness of secondary school teachers is generally bad and the level of the current issues is lacking (Harun et al, 2011).

This is also in agreement with Nurbaity, Yuli Rahmawati, and Achmad Ridwan. Their findings revealed that teachers initially have no knowledge of green chemistrybut after exposure to green chemistry class, the teachers became aware of environmental problems and to think about their future and current role as teachers. They started to reflect on the values and principles of green chemistry that can be implemented in chemistry classrooms. The study also found that the soft skills of collaboration with others, communication and argumentation skills, then creative and critical thinking skills were developed.

Alake Ese Monica (2017) in her work “Green chemistry: Senior secondary teacher’s awareness and practice in southern Nigeria” showed 40% of senior secondary school teachers have knowledge and practice green chemistry in Southern Nigeria. 60% of the teachers do not know

the meaning and do not support their environment. The results of findings revealed very low understanding and practice of green chemistry by teachers.

This is a key indicator that learners are not being exposed to current and emergent environmental issues and ways of curbing them. The findings of this study are consistent with conclusion made by Harun et al, (2011).

The findings from this study show also shows as seen in the mean score of 1.65 from responses in table 4.3 that the concept and principles of green chemistry were not emphasised and practised in the laboratory work and class room teaching despite the globally accepted need for environmental sustainability.

The results of Army Auliah, Muharram and Mulyadi (2018) also showed that, in general, the majority (97.14%) of teachers at this Indonesian school reported knowledge of Green Chemistry but only 32.30 % were aware of the concept of Green Chemistry. Furthermore, 47.42% of the teachers think that green chemistry does not need to be put into learning curriculum and 31.38% believe need to be included in the learning process. These finding demonstrate that the concept of Green Chemistry has not been socialized among chemistry teachers in Minna secondary schools. For this reason, there is a need for developing a learning model in chemistry teaching that responds to our vision for a sustainable future.

This can give an explanation to why there is still exist huge generation of and poor management of wastes that could have been avoided. Application of appropriated knowledge acquired enhances sustainable development but where there is a gap between the contemporary societal need and knowledge acquired, the expected behavioural change cannot be achieved. Failure in this made it that practicing green chemistry principles is not seen as a necessity despite the fact

that chemistry education is the major branch of science that brings us to the reality of our daily practices and the attendant effect on our environment. (Adejoh & Sambo, 2011). With concerted efforts by relevant bodies and varying approaches, the existing gap between chemistry education and drive to green chemistry can be closed.

Gender issues are very pertinent in matters of environment and environmental conservation. The findings of this study imply gender has no effect in terms of awareness and attitude.

According to studies done by Kulasekara on Environmental Awareness: Green chemistry as the way forward.It was found out that male and female teachers, rural and urban area teachers differ significantly in their Environmental Awareness (Kulasekara, 2012) This study introduces the factor of gender and various location within an urban set up in Nairobi Kenya.

The present findings are in line with the findings of Arbaat Hassan et al(2011) who no significant differences in terms of knowledge, awareness and practices towards green chemistry based on gender.

The present study revealed no significant difference between sexes across all groups, which contrasts with conclusions found by three previous studies. The conclusions in these studies were: that women have stronger environmental attitudes than men (Zelezny, Chua & Aldrich, 2000), women are more likely than men to state that current laws and regulations do not go far enough towards the protection of the natural environment (NEETF, 1998), and that women expressed greater concerns for the biosphere (Stern & Dietz, 1994).

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The study examined awareness and attitude toward implementation of green chemistry attitude among teachers in Minna Metropolis. This chapter highlights major findings, conclusions and suggestions and recommendations made**.**

5.2 Summary

The research work investigated the attitudes of secondary school chemistry teachers towards the use of electronic resources in Minna metropolis. The study was categorize mainly in to five chapters.

Chapter one discusses the following sub-headings; Background to the Study, Statement of the Problem, Aims and Objectives of the Study, research Questions, Significance of the Study, Scope of the Study and Definition of Operational terms. In this chapter three aims and objectives were acquired from three Research Questions was developed.

In Chapter two, literature related to this study was reviewed on the research and which provided the researcher with information, overview as to how far work has been done in respect to the research topic or similar topics and to create focus for the researcher.

Chapter three entails mainly the methodology employed in the study and the following subheadings was used to define the methodology; Research Design, Population of the Study,

Sampling and Sampling Techniques, Research Instruments, Validity and Reliability of the Research Instrument, Data Collection Procedures, Method of Data Analysis. This chapter is a cross-sectional descriptive survey employing the use of questionnaire in which judgemental sampling technique was used to select from the Population of the Study.

In the chapter four of this study, the data collected was interpreted in form of mean and standard deviation and inferential statistical tool to answer the research questions and test the hypotheses respectively and a brief discussion of the summary was made.

Finally, chapter five summarizes the whole research work, were conclusion was drawn and also useful and relevant recommendations were provided as well as significant suggestion for further research.

5.3 Major Findings

The study made the following findings under each of the objectives of the study.

5.3.1 Awareness on Green Chemistry

The first objective was to find out the level of awareness among chemistry teachers in Minna Metropolis. The findings of the study show that there is poor or no knowledge and awareness about Green chemistry. Similarity, in the level of awareness of Green Chemistry among male and female secondary school teachers in Minna Metropolis,the study revealed that there is no significant difference in the level of awareness among male and female chemistry teachers in Minna Metropolis. Hence, the first hypothesis was accepted.

5.3.2Implementation of Green Chemistry practises

The second objective of this study was to determine the level of implementation of Green Chemistry in public secondary school in Minna Metropolis. Furthermore, most of the teachers think that green chemistry should be taught as a separate topic and only few believe that the principles of Green Chemistry are easy and inexpensive. These finding demonstrate that the concept of Green Chemistry has not been socialized among chemistry teachers in Minna secondary schools. For this reason, there is a need for developing a learning model in chemistry teaching that responds to our vision for a sustainable future.

5.3.3 Attitudes towards Green Chemistry

The third objective of the study was to determine the attitude of chemistry teachers towards the teaching of green chemistry in Minna Metropolis. The study found out that on a general note the attitude of teachers towards Green chemistry is positive. From the responses obtained from the study, it was noted that majority of the teachers exhibited a positive attitude. The attitude towards Green Chemistry indicated that majority of the teachers will like to learn and practice Green Chemistry

The study through calculation students' t test found out that there is no significant difference in the attitudes of male and female teachers in Minna Metropolis. The second hypothesis was accepted.

5.4 Recommendations

Following the findings of the study, the following recommendations were made

1. More benign topics (Green Chemistry topics) in senior school chemistry curriculum should be encouraged.

2. Teachers should empower students with suitable mechanisms to address sustainable environment issues in classroom or laboratory instruction to promote sustainable practices among them

3. Green chemistry as a subject necessarily might be considered as an independent syllabus in Nigerian education system.

4. There should be a need to impart sustainable development knowledge through teaching and learning process.

5. The suggestion made was that Green Chemistry Education in Nigeria should be more "hands-on" to form more consistent behaviour in protecting the environment and making chemistry more appealing to students and to the public.

6. Teachers should be retrained on how to use less toxic chemistry and how to effectively carry out green chemistry practices.

7. The teaching of chemistry should reflect it's relevance to student lives and activities.

8. Since education is a vital tool in every human endeavour, it should be made as an important component of green chemistry in full incorporating it into the chemistry curriculum of the educational institutions.

9. Chemical industries in the country to switch to green practises and look for replace of toxic chemical with more benign ones.

5.5 Suggestions for Further Research

There is need for further studies on Green chemistry knowledge, attitude and participation amongst formal education set ups in Nigeria. Studies elsewhere have suggested that increased knowledge leads to better attitude and thus change in environmental behaviour. It remains to be ascertained in the thirty six (36) states of the Federation secondary schools. In the course of this study, it was found that there is need for further studies in the following areas.

1. Factors that affect teachers level of Green Chemistry awareness, attitude and participation in environmental activities.

2. Factors that affect students' level of Green Chemistry awareness, attitude and participation in environmental activities.

3. A survey of the teaching methodologies used in secondary schools and how effective they are in achieving sustainable development.

4. The relationship between Green Chemistry and the level of environmental awareness, attitudes and participation in environmental activities among students.

REFERENCES

2000 IUPAC, Pure and Applied Chemistry **72**, 1207–1228

A.S.C(2014). Chan, T.T. Huang. J.H. Wagenknecht and R.E. Miller. *J. Org. Chem.*, 60, 742

Abd. Rahman Aroff, Zakaria Kasa, 1987. "Falsafah dan Konsep Pendidikan", *Penerbit Fajar*

Adejoh M.J & Sambo M.H. (2011). Improving the Qualityl of Basic Science Teaching and Learning through Educational Reforms. *Proceedings of the 52ndl Annual Conference of the Science Teachersl Association of Nigeria (STAN).* 182-191.

Ajewole G.A., Nzewi U. & Aganga A.B. (2009). Curriculum Enrichment of Science, Technology and Mathematics Education as a Basis forl Developing Entrepreneurship Skills. *Proceedings of the 50thl Annual conference of STAN*. 26-30.

Ajzen, I. (2001). Nature and operation of attitudes. *Annual review of psychology*, *52*(1), 27-58.

Akani O. (2014). Creativity-Oriented Science and Technology Curriculum for Secondary Schools inl Nigeria: Implications for Skills Acquisition and National Development. *Proceedings of the 55th*l *Annual Conference of STAN*. 47-54

Albarracin, B.T. Johnson & M.P. Zanna (Eds.), *The Handbook of Attitudes* (pp. 743-767).

Allen, V. (2004). The changing image of chemistry. *Chemistry World,1*(2).Retrieved February 1, 2014 fromhttp://www.rsc.org/chemistryworld/Issues/2004/December/changingimage.asp

American Association of Engineering Societies home page: http://www.aaes.org/ National Collegiate Inventors and Innovators Alliance home page: http://nciia.org/

Aminrad Z, Zakaria S Z S, Hadi A S, and Sakari M 2013 World Applied Sci. J. **22** 1326–33

Aminrad, Z., S.Z.S. Zakaria, S. Hadi and M. Sakari, Environmental Health Perspectives, 115(1): 106-114. 2012. Survey on Environmental Awareness among 35.

Aminrad, Z., S.Z.S. Zakaria, S. Hadi and M. Sakari, Environmental Health Perspectives, 115(1): 106-114.2012. Survey on Environmental Awareness among Environmental Specialists and Secondary School Environmental science teachers in Malaysia. conference proceeding

Anastas PT, Warner JC (1998) Green chemistry: theory and practice. Oxford University Press, Oxford Google Scholar (http://scholar.google.com/scholar_lookup? title=Green%20chemistry%3A%20theory%20and%20practice&author=PT.%20Anastas& auth =JC.%20Warner&publication_year=1998)

Athman, J., & Monroe, M. (2000). *Elements of effective environmental education programs*. Retrieved November 12, 2003 from Recreational Boating Fishing Foundation: http://www.rbff.org/educational/reports.cfm

Bakti, Kuala Lumpur. Mak Soon Sang, 2000. "Ilmu Pendidikan untuk KPLI", Kuala Lumpur.

Ballantyne, R., & Packer, J. (1996). Teaching and learning in environmental educationKrause, D. (1993). Environmental consciousness: an empirical study. *Environment and Behavior, 25*, 126-143. Madsen, P. (1996). What can universities and professional schools do to save the environment

Bedgood D. *Chemistry in Australia*, 2008,The Chemist | Journal of the American Institute of Chemists 75(11), 22–23.

Biswas, A. K., & Agarwal, S. B. C. (2013). *Environmental impact assessment for developing countries*. London, UK: Elsevier. Borg, C., Gericke, N., Höglund, H. O., & Bergman, E. (2014). Subject- and experience-bound differences in teachers' conceptual understanding of sustainable development. *Environmental Education Research, 20*(4), 526- 551. 10.1080/13504622.2013.833584

Black, A. and E. Deci, 2000. The effects of instructors' autonomy support and students' autonomous motivation on learning organic chemistry: A self determination theory perspective. Sci. Educ., 84: 740-756. DOI: 10.1002/1098 237X(200011).

Bradley, J. D. (2002). New trends in chemistry curricula. A UNESCO-IUPAC (CTC) Workshop. *Chemical Education International, 3*(1), AN-3.

Braun, B., Charney, R., Clarens, A., Farrugia, J., Kitchens, C., Lisowski, C., Naistat, D, and O'Neill, A. (2006). Completing our education - green chemistry in the curriculum. *Journal of Chemical Education, 83*(8), 1126-1129.

Breckler, S. I. (1984). Empirical validation of affect, behavior, and cognition as distinct components of attitude. *Journal of Personality and Social Psychology, 47*, 1191-*za*1205.

Burmeister, M., and Eilks, I. (2012). Training chemistry teachers in education for sustainable development. In *Abstract Book of 22nd International Conference on Chemistry Education (ICCE) & 11th European Conference on Research in Chemical Education (ECRICE) "Stimulating Reflecting & Catalysing Change in Chemistry Education" - 15-20 July 2012 - Rome, Italy*.

Burmeister, M., Rauch, F., and Eilks, I. (2012). Education for sustainable development (ESD) and chemistry education. *Chemistry Education Research & Practice, 13*, Cann, M. C. (2001). Greening the chemistry curriculum at the University of Scranton. *Green Chemistry, 3*(2), G23-G25

Cann, M. C. (2001). Greening the chemistry curriculum at the University of Scranton. *Green Chemistry, 3*(2), G23-G25.

Cann, M. C., & Connelly, M. E. (2000). *Real-world cases in green chemistry*. Washington, DC: American Chemical Society.

Cann, M. C., and Dickneider, T.A.,. (2004). Infusing the chemistry curriculum with green chemistry using real-world examples, web modules and atom economy in organic chemistry courses? *Journal of Chemical Education, 81*(7), 977-980

Chinedu, C. (2008). Environmental education awareness of attitudes of secondary school students in Owerri Education Zone, Imo state. Unpublished M.ED. Thesis of the Department of Science Education, UNN.

Cottrell, S., 2003. Influence of socio demographics and environmental attitudes on general Evaluating user experience in green buildings in responsible environmental behavior among 28(3/4): 225-238. Behavior, 35: 347-375.

Cullipher, S G 2015 Research for the Advancement of Green Chemistry Practice: Studies in Atmospheric and Educational Chemistry Graduate Doctoral Dissertations Paper 203 http://scholarworks.umb.edu/doctoral_dissertations

DeFleur, M. L., and Westie, F.R. (1963). Attitude as a scientific concept. *Social Forces, 42*, 17-31.

Doob, L. W., 1974, Thebehavior of attitudes, *Psychological Review,* 54, 135- 156

E. M. Okonkwo, O. J. Okunola and C. S. Ezeanyanaso (2010) Sustainable Development: The role of Chemical Technology in the Industrialization of Nigeria. Journal of Sustainable Development in Africa Volume 12, No.7

Eaglewood Cliffs, NJ: Prentice HillGoes, L. F., Leal, S.H., Corio, P., and Fernandez, C. (2013). Pedagogical content knowledge aspects of green chemistry of organic chemistry university teachers. C.P.

Eagly, A. H., and Chaiken, S. (2005). Attitude research in the 21st century: the correct state of knowledge.

Eilks, I., and Rauch, F. (2012). Sustainable development and green chemistry in chemistry education. *Chemistry Education Research & Practice, 13*, 57-58.

European Association for Chemical and Molecular Sciences, EuCheMS. (2010a). *The European sustainable chemistry award*. Retrieved August 20, 2010 from http://www.euchems.org/esca/ European Association for Chemical and Molecular Sciences, EuCheMS. (2010b). *News Release: First Laureate of the Newly Launched 'European Sustainable Chemistry Award'*. Retrieved August 2010, 22 from http://www.euchems.org/binaries/ESCA2010winner_tcm23-187177.pdf

Fahlquist, J.N., 2008. Moral Responsibility for 17. Alibeli, M.A. and C. Johnson, 2009. Environmental Problems Individual or Institutional? Environmental Concern: A Cross National Analysis.

Fairley, P. (1998). Green Chemistry recognised. *Chemical Week, 160*(26), 42.

Fensham PJ. *J. Curriculum Studies*, 1985, 17, 414–35. Onuegbu, T.U & Ekemezie, P.N (2009): Overview of Green Chemistry: An effective pollution prevention. *A natural magazine of chemical society of Nigeria* (3) 3 PP23-27

Fishbein, M., and Ajzen, I. (1995). *Belief, attitude, intention, and behaviour: An introduction to theory and research*.

Gatignon, H.; Tushman, M. L.; Smith, W.; Anderson, P. A structural approach to assessing innovation: Construct development of innovation locus, type, and characteristics. *Management Science* **2002**, *48*, 1103–1122.

Gaye Teksoz, Elvan Sahin, Hamide ErtepinarSeddon, K. *Green Chem*. **2002**, *4*, G35.Rogers, R.D.; Seddon, K .*Ionic Liquids: Industrial Applications for Green Chemistry*; ACS Ser.818; Oxford University Press: Oxford, UK,**2002**.

Goes, L. F., Leal, S.H., Corio, P., and Fernandez, C. (2013). Pedagogical content knowledge aspects of green chemistry of organic chemistry university teachers. In C.P.

Haack, J., Hutchison, J. E., Kirchhoff, M. M., & Levy, I. J. (2005). Going green: Lecture assignments and lab experiences for the college curriculum. *Journal of Chemical Education, 82,* 974-978.

Hill J, (2006)'Scientific literacy and the reform of science education in Australia: A chemistry perspective', PhD

Hill J.(2010) 'Science Education must inform and influence climate change policy', *ChemEd NZ*, 2010, 118, 9–13.

HJERESEN D. L., SCHUTT D. L., BOESE J. M. Greenchemistry and education. J. Chem. Educ. 12, 1543, 2000.

Hogue, C. (2013). It's not easy being green. *Chemical & Engineering News, 91*(36), 75-79.

J. Agric. Environ. Ethics, DOI 10.1007/s10806-008- Journal of International and Cross-cultural Studies, 9134-5. 3(1). Department of the Environment and Heritage, 2005.

J. B. Callicott and F. J. da Rocha (Eds.), *Earth Summit Ethics: toward a reconstructive postmodern philosophy of environmental education*. (pp.71-91). NY: Albany State University of New York Press.

K.O. Oloruntegbe and J.O. Agbayewa, Greening the chemistry curriculum: Catching them young. *British Journal of Education, Society and Behavioral Science* . 3 (3), 2013, 223 – 232.\ Federal Government of Nigeria. *National Policy on Education*. 2004.

Karpudewan, M., Z. Ismail and N. Mohamed, 2006.Greening the high school chemistry curriculum to address education for sustainable development.Proceeding of the International Science Education Conference, Nov. 22-24, National Institute ofEducation, Singapore, pp: 1007. ISSN: 981-05-6714-6

Khor, C. Y. (2006). Environmental education Awareness among preschool teachers in di Pulau Pinang. Unpublished Master's Thesis. University Putra Malaysia.

Kirchhoff, M. (2014). *The chemistry is always greener*. Retrieved February 1, 2014 from http://www.acs.org/content/acs/en/education/students/graduate/the-chemistry-isalways greener.html

Klingshirn, M. A., and Spessard, G. (2009). Integrating green chemistry into the introductory chemistry curriculum. In P.T. Anastas, I.J. Levy, and K.E. Parent,

Kumar , A.; Jain, N. *Tetrahedron* **2005**, *61*, 1015.

La Merill, M., Parent, K., and Kirchhoff, M. (2003). Green chemistry: stopping pollution before it starts. *ChemMatters, April 2003*, 7-10.

Lall, S.; Pietrobelli, C. *Failing to Compete*; Edward Elgar Publishing, Ltd.: UK, 2002.

Lancaster, M (2002). *Green chemistry an introductory Text*, Cambridge. Royal society of chemistry,

Linthorst, J. A. (2009). "An overview: Origins and development of green chemistry". *Foundations of Chemistry*. **12**:55–68. doi:10.1007/s10698-009-9079-4 (https://doi.org/10.1007%2Fs10698-009-9079-4).

Logar, N "Chemistry, Green Chemistry, and the Instrumental Valuation of Sustainability " *Minerva* **2011**, *49*, 113–136

Maduewesi B.U. and Igbo R.O (Eds) (2004). *Issues andl Challenges in Nigerian Education in the 21st Century.* Onitsha. West and Solomon Corporatel Ideals Ltd.

Mahaffy, P. (2004). The future shape of chemistry education. *Chemistry Education Research and Practice, 5*(3), 229-245.

Mahwah NJ: Lawrence Erlbaum AssociatesFabrigar, L. R., MacDonald, T.K., and Wegener, D.T. (2005). The structure of attitudes. In

Makoni M 2013 *International Journal. of Asian Social Science*. **3** 971-91

Matus, K. J., Clark, W.C., Anastas, P.T., and Zimmerman, J.B. (2012). Barriers to the implementation of green chemistry in the United States. *Environmental Science & Technology, 46(20)*, 10892-10899. Newton, D. E. (2008). *Chemistry of the environment*. New York: Checkmark Books.

Moemeke C.D, & Efedi E.O. (2010). Science Educational and the Development of Decision Making Ability: A Curriculum Implementation Dimension. *Journal ofl Curriculum Studies. 17*(3); 137-145

Mohamed Zohir Ahmad, & Sharifah Norhaidah Syed Idros. (2005). *Kesediaan guru pelatih USM dalam menangani isu pembangunan lestari.* Paper presented at the Seminar Kebangsaan JPPG 2005 "Education for Sustainable Development", Shangri-La hotel, Pulau Pinang, 28–30 August.

Mohd Salleh Lebar, 2002. "Perancangan Pendidikan Peringkat Sekolah dan IPT", Kuala Lumpur. Garner, N.; Hayes, S.M.; Eilks, I. Linking formal and non-formal science education-A reflection from two cases in Ireland and Germany. *Sisyphos J. Educ.* **2014**, *2*, 10–31

Mohd. Zohir (2008). *What Motivates Teachers to Conduct Research*. Universiti Malaya '

Moseley, C., Reinke, K., & Bookout, V. (2002). The effect of teaching outdoor environmental education on preservice teachers' attitudes toward self-efficacy and outcome expectancy. *The Journal of Environmental Education, 34*, 9-15

Mrema, Karen, 2008. An Assessment of Student's Environmental Specialists and Secondary School Environmental Attitude and Behaviours and the Science Teachers in Malaysia. Conference Proccding, Effectiveness Their School Recycling Programs.

Musser, L., & Diamond, K. (1999). The Children's attitudes toward the environmentalPalmer, J. (1998). *Environmental education in the 21st century: theory, practice, progress and promise*. New York: Routledge.

National Environment Health Association. (1997). Design for the environment's green chemistry program. *Journal of Environmental Health, 59*(10), 41.

Newton, D. E. (2008). *Chemistry of the environment*. New York: Checkmark Books.

Nobelprize.org. (2005b). *Press Release: The Nobel Prize in Chemistry 2005*. Retrieved August 20, 2010 from http://nobelprize.org/nobel_prizes/chemistry/laureates/2005/press.html

Nurbaity,Yuli Rahmawati and Achmad Ridwan(2016). Integration Green Chemistry Approach in Teacher Education Program for Developing Awareness of Environmental Sustainability.*ASEAN Comparative Education Research Network Conference , November 30th– December 01 2016 ISBN: 978-983-2267-95-9*

Ogunjinmi, A. (2012). An Empirical Study of the Effects of Personal Factors on Environmental Attitudes of Local Communities around Nigeria's Protected Areas. *The Journal of Trans disciplinary Environmental Studies vol. 11,(1) 2012*

Okonkwo, E.M Okunola, O.J & Ezeanyanaso, C.Sl (2010). Sustainable development: The Role of Chemical Technology in the Industrialization ofl Nigeria. *Journal of Sustainable Development in*l *Africa. 12*(7) 135–146.

Okoro I. A. and Okoro S (2011) Agricultural bye products as green chemistry absorbents for the removal and recovery of metal ions from waste water. Continental J. Water, Air and Soil Pollution 2 (1): 15 – 22.13.

Orr, D., 1991. What is education for? 25 January 2009;http://www.content.org/ICLIB/IC27?Orr.htm.Oslb

Oskamp, S., and Schultz, P.W. (2005). *Attitudes and Opinions* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Palmberg, I., & Kuru, J. (2000). Outdoor activities as a basis for environmental Responsibility

Pietro, T, Anastas, P.T, Black, S.D, Breen, J, Collin T,l Memoli S., Miyamoto, J, Polyyakoff M, & Tumasl W. (2000). Synthetic Pathways and Processes inl Green chemistry: Introductory Overview. *Pure and*l *Applied Chemistry Journal. 72* (7). 1207 –1225.

Poliakoff, M.; Fitzpatrick, J. M.; Farren, T. R.; Anastas, P. T. Green chemistry: Science and politics of change. *Science* **2002**, *297*, 807–810. Goodman, S. "Green chemistry" movement sprouts in colleges, companies. *The New York Times* **2009**.

Poliakoff, M.; Licence, P. (2007). "Sustainable technology: Green chemistry". *Nature*. **450** (7171): 810–812.s

Pooley, J., & O'Connor, M. (2000). Environmental education and attitudes: emotions and beliefs are what is needed. *Environment and Behavior, 32*, 711-724. Rovira, M. (2000). Evaluating environmental education programs: some issues and problems. *Environmental Education Research, 6*, 143-155.

Riess W and Mischo C 2010 *International. Journal of Science Education*. **32** 705-25

Roberts, J. A. (2005). *Creating green chemistry: discursive strategies of a scientific movement.* Unpublished Ph.D. Thesis in Science & Technology Studies, Faculty of Virginia Polytechnic Institute & State University.

Rusilawati, O., & Zainon, A, M. (2009). Pedagogical Content Knowledge in the Malaysian School Science Curriculum. In O. De Jong, & H. Lilia (Eds.), *Teachers' Professional Knowledge in science and Mathematics Education: Views from Malaysia and Abroad*. Selangor: Faculty of Education, nationa

Santosa and Sri Juari 2008 *Kimia Hijau Sebagai Pilar Utama Pembangunan Lestari.*lib.ugm.ac.id/digitasi/upload/717_pp110600020.pdf . diakses 19 Februari 2014

Sharifah, N.S.I. and Y.N. Hashimah, 2006. Malaysian pre and in-service teacher prepareness in teaching for sustainability. Proceeding of the 2006 International Organization of Science and Technology Education, July 30 Aug. 4 Penang, Malaysia, University Sains Malaysia, ISBN: 983- 2700-39-6, pp: 809.

Shiyakumar G. (2011). Environmental Attitude among the Secondary School Students. *Indian Streams Research Journal Vol.1, 11pp.1-4*

Stern, P., 2000. Psychology and the science of human environment interactions. Am. Psychol., 55: 523-530. PMID: 10842433

Taylor, D. A. (2010). Principles into practice: setting the bar for green chemistry. *Environmental Health Perspectives, 118*, a254-a257.

Thurstone, L. L., 1928, Attitudes Can Be Measured, *The American Journal of Sociology,* Vol. 33, No. 4, pp. 529-554.

Tuncer, G., Tekkaya, C., Sungur, S., Cakiroglu, J., Ertepinar, H., & Kaplowitz, M. (2009). Assessing pre-service teachers' environmental literacy in Turkey as a mean to develop teacher education programs. *International Journal of Educational Development, 29*, 426–436. M. Poliakoff, P. Licence Nature, 450 (2007), pp. 810-812

Tushman, M.; Smith, W. Innovation Streams, Organization Designs, and Organizational Evolution. In *Managing Strategic Innovation and Change*; Oxford University Press: New York, 2004; Vol. 2, p. 2.

Uchegbu, R.I, Oguoma, C.C., Elenweko, U.E.,Ogbugbu, O.E., 2016. "Perception of Difficult Topics in Chemistry Curriculum by Senior Secondary School II Students in Imo State" AASCIT Journal of Education, 2(3): 18-23.

UNEP, (2012). 21 Issues for the 21st Century: Result of the UNEP Foresight Process on Emerging Environmental Issues. United Nations Environment Programme (UNEP), Nairobi, Kenya.

UNESCO (1978). *Intergovernmental conference on environmental education*. Tbilisi (USSR), 14-26 October 1977. Final Report. Paris: UNESCO

Van-Ejick, M. & Roth, W.M. (2007). *Improving Science Education for Sustainable Development*. PL Biology, 5, 2763-2769.

Wardenchi, W., Curylo, J. and Namiesnik, J. (2005). Green chemistry: Current and future issues. *Polish Journal of Environmental Studies, 14*(4), 389-395.

Ware, S. A. (2001a). Greening the curriculum. American Chemical Society education programs. *Pure & Applied Chemistry (IUPAC), 73*(8), 1247-1250 Cambridge University Press.

Williams, E. N., Hurley, K., O'Brien, K. & DeGregorio, A. (2003).*Development and Validation of the Self-Awareness and Management Strategies (SAMS) Scale for Therapists*. Psychotherapy: Theory, Research, Practice, Training, 4(40), 278.

Yarkandi, A.H. anb N.H. Yarkandi, 2012.Strengthening Environmental Education Curricula. Journal of Education and Vocational Research, 3(8): 264-270.

Yusuf F.N., Ali, Z.M. 2012. "Urban Students' Attitude Towards Learning Chemistry". Procedia Social and Behavioral Sciences, 68: 295-304

Zelezny, L., Chua, P., & Aldrich, C. (2000). Elaborating on gender differences in environmentalism. *Journal of Social Issues, 56*, 443-457.

Zimmermann, L. (1996). The development of an environmental values short form. *Thel Journal of Environmental Education, 28*, 32-37.*l* 97

APPENDIX I

Green Chemistry Questionnaire (GCQ)

Introduction

This questionnaire is intended solely for research purpose. This research study is being carried out on the Awareness and Attitude towards Implementation of Green Chemistry among Chemistry Teachers in Minna. Every information will be considered with utmost confidentiality.

Section A: Demographic Data

Sex: Male ☐ Female ☐

Working experience

1-5 ☐ 6-10 ☐ 11-15 ☐ 15-above ☐

Qualification

NCE ☐ HND ☐ B.SC ☐ M.Sc ☐ Others ☐

Key:

SA= Strongly Agree

A= Agree

D= Disagree

SD= Strongly Disagree

Answer each question in sections B to D by ticking the option corresponding to the statement that indicates your opinion.

Section B: Awareness of Green Chemistry

S/N	Items	SA	A	D	SD
1	I have an understanding of what is meant by environmental chemistry				
2	I have an understanding of what is meant by 'green chemistry'				
3	Environmental chemistry and green chemistry are pretty much the same thing				
4	Green chemistry is just a more catchy term for environmental chemistry				
5	Green chemistry is a new dimension of environmental chemistry				
6	Green chemistry tries to prevent pollution before it starts				
7	Green Chemistry tries to protect the environment by identifying possible				

	sources of pollution and treating pollutant, but it should be doing more than that				
8	Green chemistry helps us change the wrong perception of people that chemistry is the main cause of environmental hazards				
9	I am aware of the twelve principles of Green chemistry				
10	Green chemistry can help achieve sustainability				

SECTION C: Attitude towards green chemistry

Green Chemistry is the utilization of set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products.

S/N	Items	SA	A	D	SD
1	I think the ways of teaching chemistry must change and include green chemistry so as to appeal more to students				
2	I will like to include concepts of green chemistry in my teaching				
3	Students are generally more interested in learning about green chemistry than about more traditional topic				
4	I think green chemistry principles are too expensive and has no place in the Nigerian chemistry curriculum				
5	I think it is more important to study the foundations of chemistry than to introduce green chemistry in secondary schools				
6	I think the best way to introduce green chemistry to O-level student is by studying it as a separate topic				
7	I think the principles of green chemistry are easy to apply				
8	There is no need introducing green chemistry because chemistry cannot be rendered green				
9	The principles of green chemistry are hard to apply				
10	I think it is useless studying green chemistry since there are no suitable textbooks at the secondary level				

SECTION D: Level of Implementation

S/N	Items	Very often	Often	Seldom	Never
1	In my teaching I relate chemistry to everyday life				
2	I Include green chemistry concepts in the classroom and laboratory work				
3	I Perform reaction involving the release of gas in a fume cupboard				
4	I Close fume hoods when not in use to reduce energy use				
5	I Neutralize base or acid to pH 7 before pouring down the drain				
6	I use green solvent such as green solvents like ionic liquids, supercritical CO2 fluid instead of alcohol or benzene				
7	I run experiments on the microscale to reduce waste				
8	Recycle pipette tip boxes, and water purification cartridges				

Appendix II

Names of Secondary Schools in Minna metropolis and the number of Chemistry Teacher.

LGA	S/N	Name of School	No of Chemistry Teachers
Bosso	1	Bosso secondary school Minna	**3**
„	2	Day Secondary School Chanchaga Minna `B`	**2**
„	3	Day secondary school Maitubi Minna	**3**
„	4	Day secondary school Pyata Bosso	**2**
„	5	Federal Government College Minna	**5**
„	6	Government Army Day Secondary School	**3**
„	7	Government Science college Chanchaga	**2**
„	8	Government Technical College Minna	**3**
„	9	Maryam Babangida Girls Science College	**3**
„	10	Model science college Tudun Fulani	**3**
„	11	Niger State School for Special Education Minna	**2**
„	12	Sheikh Muhammad Sanbo College of art and Islamic studies Tudun Fulani Minna	**-**
„	13	Sir Ahmadu Bello Model Secondary School	**3**
Chanchaga	14	Ahmadu Bahago Secondary School Minna	**2**
„	15	Day Secondary School Limawa Minna	**2**
„	16	Fr. O'Connel Science College Minna	**3**
„	17	Governemnt Day Secondary School Bosso Road	**2**
„	18	Government Day Science College Tunga	**2**
„	19	Government Girls Science College Bosso Road Minna	**2**
„	20	Government Girls Secondary School Minna	**3**
„	21	Government Vocational Centre	**2**
„	22	Woman Day College	**1**
„	23	Zurumai Model School	**3**
			Total 51

Source : Niger State Ministry of Education, 2018-2019 ACS Report.

APPENDIX III

Table 3.2: Names of sampled schools and numbers of Chemistry Teachers

LGA	S/N	Name of School	No of Chemistry Teachers
Bosso	1	Bosso secondary school Minna	3
„	2	Day Secondary School Chanchaga Minna `B`	2
„	3	Day secondary school Maitubi Minna	3
„	4	Day secondary school Pyata Bosso	2
„	5	Federal Government College Minna	5
„	6	Government Army Day Secondary School	3
„	7	Government Science college Chanchaga	2
„	8	Government Technical College Minna	3
„	9	Maryam Babangida Girls Science College	3
„	10	Model science college Tudun Fulani	3
„	11	Sir Ahmadu Bello Model Secondary School	3
Chanchaga	12	Ahmadu Bahago Secondary School Minna	2
„	13	Day Secondary School Limawa Minna	2
„	14	Fr. O'Connel Science College Minna	3
„	15	Governemnt Day Secondary School Bosso Road	2
„	16	Government Day Science College Tunga	2
„	17	Government Girls Science College Bosso Road Minna	3
„	18	Government Girls Secondary School Minna	2
„	19	Zurumai Model School	3
Source: Niger State Ministry of Education ACS report		Total	50

APPENDIX IV
INTRODUCTION LETTER

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

School of Science and Technology Education

DEPARTMENT OF SCIENCE EDUCATION

Vice Chancellor: Prof. Abdullahi Bala, PhD, fssn
H.O.D.: Dr. (Mrs.) R. W. Gimba B.Ed., M.Tech, PhD Mathematics Education

Federal University of Technology,
P.M.B. 65,
Minna, Niger State.
Nigeria.

Your Ref: _____

Our Ref: _____

Date: 19th JUNE, 2019

The Director,
School Service
Niger State Ministry of Education

TO WHOM IT MAY CONCERN

The bearer Kingsley Luka With REG. No 2016/3/16414BSE is a undergraduate (B/TECH) student of Science Education Department He/She needs your assistance to enable him /her carry out his research work.

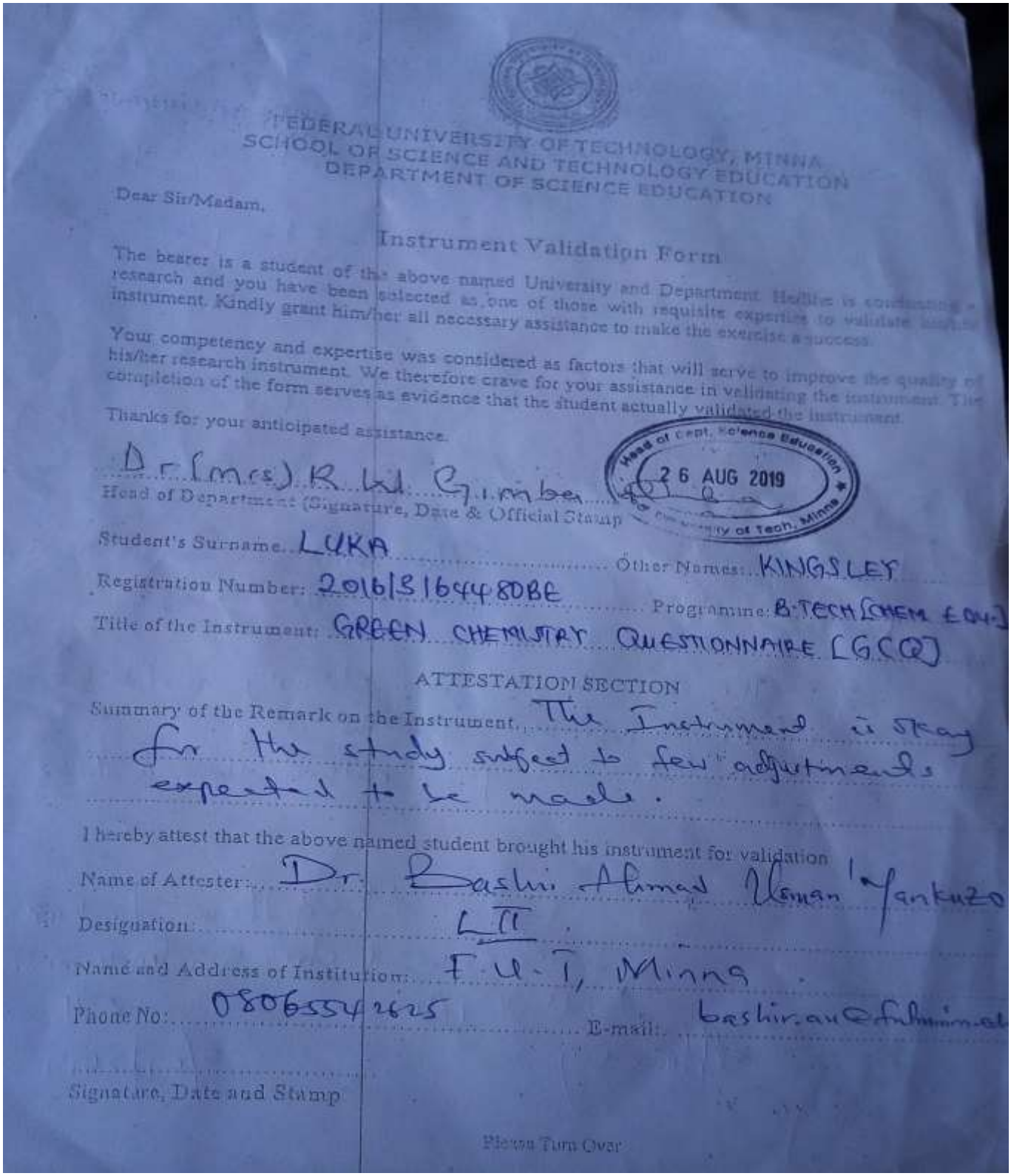
We will appreciate your anticipated co-operation.

Thank you.

19 JUN 2019

(Mrs) R.W. Gimba
HOD

APPENDIX V
Validation Forms



FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF SCIENCE EDUCATION

Dear Sir/Madam,

Instrument Validation Form

The bearer is a student of the above named University and Department. He/She is conducting a research and you have been selected as one of those with requisite expertise to validate [illegible] instrument. Kindly grant him/her all necessary assistance to make the exercise a success.

Your competency and expertise was considered as factors that will serve to improve the quality of his/her research instrument. We therefore crave for your assistance in validating the instrument. The completion of the form serves as evidence that the student actually validated the instrument.

Thanks for your anticipated assistance.

Dr (Mrs) R. W. Gimba
Head of Department (Signature, Date & Official Stamp

Head of Dept. Science Education
26 AUG 2019
Fed. Univ. of Tech. Minna

Student's Surname: LUKA Other Names: KINGSLEY

Registration Number: 2016/S/164480BE Programme: B.TECH (CHEM EDU.)

Title of the Instrument: GREEN CHEMISTRY QUESTIONNAIRE (GCQ)

ATTESTATION SECTION

Summary of the Remark on the Instrument: The Instrument is okay for the study subject to few adjustments expected to be made.

I hereby attest that the above named student brought his instrument for validation

Name of Attester: Dr. Bashir Ahmad Usman Yankuzo

Designation: LIT.

Name and Address of Institution: F.U.T, Minna

Phone No: 08065542625 E-mail: bashir.au@futminna.edu

Signature, Date and Stamp

Please Turn Over

Please comment on the following:

1. Appropriateness of the instrument for the purpose it's designed for: The Instrument is appropriate for the study.
2. Clarity and simplicity of the language used: Satisfactory
3. Suitability for the level of the targeted audience: Okay.
4. The extent in which the items cover the topic it meant to cover: The items need to be adjusted.
5. The structuring of the Questionnaire: Okay.
6. Others (grammatical errors, spelling errors and others): Satisfactorily.
7. General overview of the instrument: The Instrument is generally good & okay for the study.

Suggestions for improving the quality of the instrument

1. The aspect of green chemistry need to be more pronced in the items.
2. Consider use of 5 rather than 4 L.S.
4.
5.

Name of Validator: Dr. Bashir Ahmad Usman Yankuzo.

Areas of Specialization: Science Education (Mathematics)

Name of Institution: F.U.T. Minna Designation: L II

Signature: [signature] Date: 5/09/2029

Thank You

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA
SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF SCIENCE EDUCATION

Dear Sir/Madam,

Instrument Validation Form

The bearer is a student of the above named University and Department. He/She is conducting a research and you have been selected as one of those with requisite expertise to validate his/her instrument. Kindly grant him/her all necessary assistance to make the exercise a success.

Your competency and expertise was considered as factors that will serve to improve the quality of his/her research instrument. We therefore crave for your assistance in validating the instrument. The completion of the form serves as evidence that the student actually validated the instrument.

Thanks for your anticipated assistance.

Dr (mrs) R Ld Gimbe
Head of Department (Signature, Date & Official Stamp

Head of Education
23 SEP 2019
Fed. University of Tech. Minna

Student's Surname: LUKA Other Names: KINGSLEY

Registration Number: 2016/3/64480BE Programme: CHEMISTRY EDU & TE

Title of the Instrument: Green Chemistry Questionnaire [GCQ]

ATTESTATION SECTION

Summary of the Remark on the Instrument

Needs a little restructuring to determine Awareness and level of implementation by chemistry teachers in M-C.

I hereby attest that the above named student brought his instrument for validation

Name of Attester: Dr. Rabiu M. Zello

Designation: Snr. Lecturer.

Name and Address of Institution: Dept. of Science Educ.

Phone No: 08035927009 E-mail: dmrabiu@futminna.ng

Signature, Date and Stamp

Please Turn Over

Please comment on the following:

1. Appropriateness of the instrument for the purpose it's designed for
   Adequate
2. Clarity and simplicity of the language used
   Okay
3. Suitability for the level of the targeted audience
   Suitable for Awareness and level of implementation
4. The extent in which the items cover the topic it meant to cover
   Adequate
5. The structuring of the Questionnaire
   Suggestion highlighted.
6. Others (grammatical errors, spelling errors and others)
   checked
7. General overview of the instrument
   Adequate

Suggestions for improving the quality of the instrument

1.
2. Areas of improvement identified
3. and highlighted for the
4. researcher.
5.

Name of Validator: Dr. Rabia M. Zeb

Areas of Specialization: Science Edu (Biology)

Name of Institution: FUTM Designation

Signature: Date 23-09-19

Thank You