TEACHERS' PERCEPTION ON REPLACING TRADITIONAL CHEMISTRY EXPERIMENTS WITH GREEN CHEMISTRY EXPERIMENTS IN SECONDARY SCHOOLS IN AKWA IBOM STATE, NIGERIA.

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Abstract
The study investigated teachers' perception on replacing traditional chemistry experiments with Green chemistry experiments. The design adopted for this study was a survey research design. The study was carried out in public secondary schools in Akwa Ibom State, Nigeria. The population of the study comprised two thousand, nine hundred and fifty (2, 950) senior secondary chemistry teachers in Akwa Ibom State. Criterion sampling technique was used to obtain one hundred and four (104) senior secondary schools chemistry teachers in the study area. The Green Chemistry Experiment (GCE) Questionnaire was the instrument used for data collection developed by the researchers. Instrument validation was done by three senior lecturers in the Department of Science Education, Physical Sciences and Measurement and Evaluation Units all from Akwa Ibom State University. The reliability coefficient of the instrument was .80 determined using Cronbach alpha formulae. Descriptive statistics of mean and standard deviation were used to answer three research questions. Findings of the study revealed that green chemistry experiments are relevant in secondary schools and that implementing green chemistry experiments in secondary schools is feasible. Findings on the nature of green chemistry experiments in secondary schools showed that participants opined that the materials for green chemistry experiments are hazard free, and that it is relatively safe to carry out green chemistry experiments in the laboratory, it prevents wastage and synthesize safer chemicals and enhance students' achievement. Based on the findings, it was concluded that green chemistry if well presented represents positive ideas of chemistry education that can bring together the concepts in chemistry through the collective purpose of sustainability.

Key words: Green chemistry, Traditional chemistry, experiments, Teachers Perception, Secondary schools.

Introduction

Nigeria's situation is characterised by high rates of population growth, different lifestyles, consumption pattern, waste disposal and other environmental issues, as well as economic and industrial development. Humans are afflicting many of the earth's critical resources, not only locally, but also at a global scale with potential effects on human and ecological health as well as the issue of environmental sustainability (Akpan, Offiong & Udosen, 2019; Akpan, & Udo, 2016).

Akpan, (2016) identified several problem militating against sustainability of the environment in Nigeria to include pollution, deforestation, global warming and slum development. Consequently, Nigeria faces huge challenges of environmental sustainability, which makes educating people about new approaches to protect the environment very important.

It calls for a movement towards emerging sustainable practices (Owoyemi & Moju, 2020). As the success of environmental sustainability depends on educating and equipping the new generation of chemists and teachers with the knowledge and skills to practice environmentally friendly chemistry (Umanah, & Udoh, 2021).

Over the past centuries, chemistry as a subject has played a major role in improving human life; chemistry is also an important discipline that contributes to the design and implementation of sustainable development strategies. It is an important subject through which sustainable concepts and principles can be integrated into teaching/learning process to equip future scientist to tackle complex environmental problems (Owoyemi & Moju, 2020)

Chemistry teaches that everything that is seen, touched and felt is made up of elements and combination of elements. Elements are the constituents of matter, so, the study of chemistry makes their interactions and existence universal (Hurd, 2013). Therefore, the science of chemistry has through creativity and innovation expanded the understanding of the structure and nature of matter. This has led to the development of new techniques in the production of new drugs and other products.

Concepts in chemistry are often described as being abstract and difficult to understand by students. This is because most of the concepts are taught without the practical experiments to enable students have full understanding, knowledge and application of such concepts. Chemistry being a practical based subject should be taught in such a manner. Educators in chemistry regard chemistry experiments as very important for various reasons which include motivation, concept learning and the development of skills and appropriate scientific attitudes (Demircioğlu, Aslan & Yadigaroğlu (2012); Olatunbosun (2015).

West African Examination Council advocated in its syllabus the rationale for the teaching of chemistry to include among others; understanding of basic science concepts, acquisition of laboratory skills, awareness of linkage between science and industry/environment and everyday life in terms of benefits and hazards and acquiring skills of critical and logical thinking (Etiubon & Udoh, 2017). Since chemistry has the potential to solve societal problem to achieve sustainable development as people constantly interact with chemicals and industry in order to improve the quality of lives through socioeconomic empowerment and skill acquisition for self reliance and wealth creation (Etiubon, Akpan & Udosen, 2018. Practices in chemistry have polluted the environment accidentally at some stage during experimentations and other practices. The objectives that science be learnt through experimentation by doing practices and making thorough observations that give meaning and relevance to understanding science (Etiubon and Udoh, 2017). Therefore, chemistry should be adequately taught through experiments to acquire valuable life time knowledge and skills.

Experiments in chemistry are done in the laboratory with the aid of manuals or teachers' guide. It is the act of engaging the students with hands-on activities. This enables them to develop scientific knowledge and is more effective when the learning objectives are clear (Okoye, 2013). It also makes difficult and abstract concepts to be real, increases curiosity and interest through the use of different materials that promotes understanding and experience. Akpan (2018a) sees the use of laboratory facilities as being very essential for good science teaching and learning as it involves manipulation of some equipment and other science laboratory materials.

Traditional chemistry experiments involve teachers presenting information in lecture-style, demonstrating skills and directing students to mimic the steps, showing students how to solve problems rather than providing tools and teaching them how to use them to solve problems. This leads students to one "right" answer and evaluates students almost exclusively with paper-and-pencil tests. Traditional chemistry experiments at all levels are teaching in laboratory settings where students follow procedures directing them to mix chemicals, make measurements, analyze data, and draw conclusions. The goals and desired outcomes of these experiments are the subject of considerable debate. Important aspects of the debate are centered

round the value versus cost of any laboratory experience and safety versus hazards of chemicals. However, Akpan (2018b) noted that science education research, innovation and practices must become more responsive to the needs and ambitions of the society and reflect its values. The challenge with the traditional experiments is that it is not hazard free. Chemistry teachers and students encounter hazards during experiments. Feierabend & Eilks (2010) observed that chemistry is the cause of every environmental problem in existence. Although it was often believed that traditional chemistry experiments did not want to harm the environment, they just did not have access to safer alternative processes and procedures that would be economically and environmentally compatible (Freiraband & Eilks, 2010).

While chemistry is one of the most significant sciences, its branches make it even more diverse and critical. Despite the importance of chemistry in education for sustainability, studies have shown that teachers at all levels struggle to apply the ideas of education for sustainable development and green chemistry in teaching through chemistry.

Green chemistry is a positive idea of chemistry education that brings together the concepts in chemistry through the collective purpose of sustainability. Anastas & Warner (2000) define green chemistry as "the utilization of a set of principles that reduce or eliminates the use of; or generation of hazardous substances in the design, manufacture and application of chemical products". In other words, rather than waiting to remediate problems, the principles are designed for primary pollution prevention at the source. This should spore teachers and students to be more creative and innovative in chemistry (Anastas & Warner ,2000).

Green chemistry is said to be the home of cutting-edge research on the development of alternative sustainable technologies (Doody,2018). Therefore, using sustainability principles as a framework for practice, green chemistry offers a primary, context based, in-practice approach to teaching chemistry (Feierabend and Eilks, 2010; Penuel, 2014). Green chemistry experiments take different approaches. It involves the creation of chemical products and processes that reduce or eliminate the use and production of harmful substances. One of its fundamental goals is to synthesize chemicals that are not hazardous for human health and the environment.

The principles of green chemistry include: preventing wastage, maximizing atom economy, designing less hazardous chemical syntheses, designing safer chemicals and products, using safer solvents/reaction conditions, increasing energy efficiency, using renewable feedstocks and avoiding chemical derivatives (Anastas & Warner, 2000). The principles was developed by Anastas & Warner (2000) to address the fact that chemistry is the cause of every environmental problem in existence (Feirabend and & Eilks, 2010). To achieve the goal of hazard free chemistry experiments efficiently, chemistry teachers and chemists in general must be able to assess potential hazards of the chemicals that they develop and utilize.

According to Doody (2018), Green Chemistry has been shown to be cost-effective, in that it minimizes costs related to laboratory supplies, safety equipment and hazardous waste disposal. Many of the materials used in green chemistry laboratories are every-day chemicals which can be found in the home. Unlike many other educational programs, green chemistry laboratories if designed to replace traditional laboratories can be accessed through a number of free online sources (Andraos & Dicks, 2012).

Green chemistry claims to produce positive gains in both students' achievement and motivation (Karpudewan, Ismail, & Roth, 2012), as well as facilitating students' personal development (DeJong & Talanquer, 2015; Sjostrom, Rauch & Eilks, 2015; Taber, 2015). Some researchers claim that Green Chemistry content facilitates students' personal development in education through chemistry, rather than chemistry through education, by emphasizing the socially mediated context of sustainability (DeJong & Talanquer,2015; Sjostrom, Rauch, & Eilks, 2015; Taber, 2015). Other research claims that teaching chemistry in a Green Chemistry framework produces positive gains in both students' achievement and motivation because students feel 'empowered' by the local approach to a global challenge (Karpudewan, Ismail, & Roth, 2012).

Green Chemistry experiments are relevant in terms of students' experiences before, during, and after secondary education, which is thought to expand students' perceptions and world views beyond the laboratory (Mandler, Mamlock-Naaman, Blonder, Yayon & Hofstein, 2012). It is not presented as an intervention or add-on course, but as "a new way of thinking about science in a responsible manner so that the lives of future generations are not compromised by today's actions" (Karpudewan, Ismail & Roth, 2012).

Once teachers and students understand that they can influence the consequences of chemistry through their actions, their sense of responsibility increases, and dependence on traditional methods may decrease (Bandura, 2007). This holds far reaching benefits that has the potential to constantly buttress positive changes in teachers and their engagement in Green Chemistry experiments. Hence, the need for this study on teachers' perception on replacing traditional chemistry experiments with Green chemistry experiments.

Statement of Problem

The National Science Education Standard and other science education literature emphasize the importance of rethinking the role and practice of chemistry and science teaching in general. The world is now more interested in conservation of resources and sustainability or sustainable process to create a healthier environment. Green chemistry also called sustainable chemistry help to save and conserve the environment through waste prevention, reduce and prevent environmental pollution, allows scientists to reduce derivatives and promote the synthesis of safer chemicals. Despite the importance of chemistry in education for sustainability, studies have shown that teachers at all levels struggle to apply these emerging sustainable practices. The national policy on education maintains that no education system can rise above the quality of its teachers, this call for the need for teachers to embrace these sustainable teaching practices. It is difficult to say if the chemistry teachers will embrace this emerging trend. This leads to the pertinent question, how do chemistry teachers perceive replacing traditional chemistry experiments with green chemistry experiments?

Purpose of the study

The purpose of this study was to find out teachers' perception on replacing traditional chemistry experiments with Green chemistry experiments in secondary schools in Akwa Ibom state. Specifically, the objectives of the study were to;

1. Determine the relevance of green chemistry experiments in secondary schools
2. Determine the feasibility of implementing green chemistry experiments in secondary schools
3. Determine the nature of green chemistry experiments in secondary schools
4. Determine the effectiveness of green chemistry experiments in secondary schools

Research Questions

The following research questions guided the study.

1. What is the relevance of green chemistry experiments in secondary schools?
2. What is the feasibility of implementing green chemistry experiments in secondary schools?
3. What is the nature of green chemistry experiments in secondary schools?
4. What is the level of effectiveness of green chemistry experiments in secondary schools?

Methodology

The design adopted for this study was survey research design. The study was carried out in public secondary schools in Akwa Ibom State. The population of the study comprised all the two thousand, nine hundred and fifty (2, 950) senior secondary chemistry Teachers in Akwa Ibom State. Criterion sampling technique was use to obtain one hundred and four (104) Senior Secondary Chemistry Teachers in the study area. The Green chemistry experiment (GCE)

Questionnaire was the instrument used for data collection developed by the researchers. It consisted of twenty- items on green chemistry comprising of: Relevance of green chemistry experiments; Feasibility of implementing green chemistry experiments, Nature of green chemistry and effectiveness of Green chemistry experiments. It consisted of a 4 points likert scale of Strongly Agree (SA), Agree (A), Disagree (DS), and Strongly Disagree (SA) scored as 4, 3. 2 and 1 respectively for all positive items and the reverse for all negative items.

Instrument validation was done by three senior lecturers in the Departments of Science Education and Chemistry Akwa Ibom State University. The reliability coefficient of the instrument was .80 determined using Cronbach alpha formulae. In order to obtain high return rate, the GCE Questionnaire was administered to the chemistry teachers in all the schools sampled for the study and retrieved immediately. Data obtained were analysed using descriptive statistics of mean and standard deviation.

Result

The results are presented according to the research question in tables 1-4.

Research question one: What is the relevance of green chemistry experiments in secondary schools?

Table 1: Mean and Standard deviation of responses on Green Chemistry Experiment Questionnaire.

S/No	Items	Mean	SD	Decision
	Relevance of green chemistry experiments			
1.	It is relevant in terms of improving students' interest in chemistry	3.35	0.73	Accepted
2.	It is relevant in terms of students' experiences during secondary education	3.55	0.74	Accepted
3.	It is relevant in terms of students' experiences after secondary education	3.59	0.67	Accepted
4.	It expands students' perceptions of chemistry	3.44	0.65	Accepted
5.	It expands students' world views beyond the laboratory	3.30	0.86	Accepted

Results in Table 1 indicated that the participants (teachers) agreed to all items in numbers 1-5. These items were all accepted because they all scored above the criterion mean of 2.50. This shows that green chemistry experiments are relevance in secondary schools.

Research question two: What is the feasibility of implementing green chemistry experiments in secondary schools?

Table 2: Mean and Standard deviation of responses on Green Chemistry Experiment Questionnaire.

S/No	Items	Mean	SD	Decision
	Feasibility of implementing green chemistry experiments			
1.	It is possible to carry out green chemistry experiments in the laboratory	3.53	0.66	Accepted
2.	There are materials for green chemistry experiments around us	3.17	0.87	Accepted
3.	The current chemistry curriculum aligns with the use of green chemistry experiments	2.30	1.18	Rejected
4.	Teachers can adjust to the use of green chemistry experiments in practice	3.55	0.74	Accepted
5.	Students can adjust to the use of green chemistry experiments	3.47	0.66	Accepted

Results in Table 2 indicated that the participants (teachers) agreed to items 1, 2, 4 and 5. They were accepted because they scored above the criterion mean of 2.50. However, chemistry teachers disagreed with item 3 which is below the criterion mean of 2.50 and so was rejected. This implies that the current curriculum does not align with the use of green chemistry experiments in secondary schools.

Research question three: What is the nature of green chemistry experiments in secondary schools?

Table 3: Mean and Standard deviation of responses on Green Chemistry Experiment Questionnaire.

S/No	Nature of green chemistry as compared to Traditional chemistry experiment	Mean	SD	Decision
1.	Materials for green chemistry experiments are hazard free	3.51	0.63	Accepted
2.	It is relatively safe to carry out green chemistry experiments in the laboratory	2.52	1.06	Accepted
3.	Green chemistry experiments prevent wastage	2.85	0.99	Accepted
4.	Green chemistry experiments synthesize safer chemicals	3.37	0.77	Accepted
5.	Materials for Green chemistry experiments are less expensive	2.30	1.18	Rejected

Results in Table 3 indicated that the participants (teachers) agreed to items 1, 2, 3 and 4. They were accepted because they scored above the criterion mean of 2.50. However, chemistry teachers disagreed with item 5 which is below the criterion mean of 2.50 and so was rejected. This implies that materials for Green chemistry experiments are not less expensive.

Research question four: What is the effectiveness of green chemistry experiments in secondary schools?

Table 4: Mean and Standard deviation of responses on Green Chemistry Experiment Questionnaire.

	Effectiveness of Green chemistry experiment	Mean	SD	Decision
1.	It enhances student achievement	2.52	1.06	Accepted
2.	It enhances affective development	3.40	0.75	Accepted
3.	It promotes motivation	3.50	0.77	Accepted
4.	It promotes practical skills acquisition	3.40	0.75	Accepted
5.	It facilitates students' personal development	2.30	1.18	Rejected

Results in Table 4 indicate that the participants (teachers) agreed to items 1, 2, 3 and 4 so they were accepted because they scored above the criterion mean of 2.50. However, chemistry teachers disagreed with item 5 which is below the criterion mean of 2.50 and so was rejected. This implies that green chemistry does not facilitate students' personal development.

Discussion of Finding

The results of this study showed that green chemistry experiments are relevant in secondary schools (Table 1). This means that Green Chemistry as a reformist and positive idea of chemistry education is relevant in that it brings together the concepts in chemistry through the collective purpose of sustainability. This is in line with Mandler, *et al.,* (2012) who stated that Green Chemistry experiments are relevant in terms of students' experiences before, during, and after secondary education, which is thought to expand students' perception and world views beyond the laboratory. Karpudewan, *et al.,* (2012) observed that green chemistry is relevant to the extent that it is not presented as an intervention or add-on course, but as "a new way of thinking about science in a responsible manner so that the lives of future generations are not compromised by today's actions". In support of this, Akpan (2016) observed that a learner develops autonomy in learning when derives the meaning from the learning content. This is what green chemistry experiments offer to learners.

The findings of the study also revealed that implementing green chemistry experiments in secondary schools is feasible (Table 2). This is in line with the assertion by Etiubon and Udo (2017) that science be learnt through experimentation by doing practices and making thorough observations that give meaning and relevance to understanding science. Also based on the objectives of the West African Examination Council, understanding of basic science concepts, acquisition of laboratory skills, awareness of linkage between science and industry/environment and everyday life in terms of benefits and hazards and acquiring skills of critical and logical thinking is the aim of science syllabus (Achimugu, 2014). However, teachers disagreed with the fact that it is possible to implement green chemistry experiments in secondary schools. This goes to reveal teachers' mind-set that despite the desire to implement green chemistry experiments in schools the curriculum has not spelt it out. This finding is in line with the study by Akpan (2019) on perceived strategies to be adopted to improve the quality of science education curriculum, in which majority of the science teachers in Akwa Ibom State, Nigeria agreed with making the science curriculum relevant through reformation.

Findings on the nature of green chemistry experiments in secondary schools (Table 3) shows that participants opined that the materials for green chemistry experiments are hazard free, relatively safe to carry out green chemistry experiments in the laboratory, prevent wastage and synthesize safer chemicals. This is in line with Anastas & Warner (2000) that developed the principles of green chemistry that it utilizes a set of principles that reduces or eliminates the use of generation of hazardous substances in the design, manufacture and application of chemical products. In addition, teachers disagreed with the notion that materials for Green chemistry experiments are less expensive with a low means of 2.30 in Table 3. This is in contrast to Doody (2018) that Green Chemistry has been shown to be cost-effective, in that it minimizes costs related to laboratory supplies, safety equipment and hazardous waste disposal. This implies that

materials used in green chemistry laboratories for experiments can be found in our environments.

The findings of the study also revealed the effectiveness of green chemistry experiments in secondary schools (Table 4). It showed that green chemistry experiments enhanced students' achievement although with a low means of 2.52 almost at the cut off mean of 2.5. It enhances affective development, motivation and practical skills acquisition. This is in line with Karpudewan, Ismail, & Roth (2012) who state that Green chemistry claims to produce positive gains in both students' achievement and motivation because students feel 'empowered' by the local approach to a global challenge. This implies that students' interest is drawn to what is globally accepted and wants to be part of it.

Teachers disagreed with the fact that green chemistry facilitates students' personal development. This is in contrast to De Jong & Talanquer (2015); Sjostrom, Rauch & Eilks (2015) and Taber (2015) that green chemistry facilitates students' personal development. Green Chemistry context facilitates students' personal development as education through chemistry, rather than chemistry through education, by emphasizing the socially mediated context of sustainability (DeJong & Talanquer, 2015; Sjostrom, Rauch, & Eilks, 2015 and Taber, 2015). This means that the exposure of students to readily available green chemistry experiments will improve personal drive in students.

Conclusion

Green chemistry if well-presented represents positive ideas of chemistry education that can bring together the concepts in chemistry through the collective purpose of sustainability. Through this sustainability principle, green chemistry offers a primary, context based, practical approach to the teaching of chemistry. Thus, green chemistry experiment should provide that laboratory experience that will have great influence on the learners on transfer of knowledge.

Recommendations

Based on the findings, the following recommendations are made:

1. The current senior secondary school chemistry curriculum should be revised to include green chemistry experiments and concepts.
2. There should be the provision of materials for green chemistry experiments to serve as encouragement to teachers by the ministry of education and other stake holders in education.
3. The chemistry teachers should adopt clearly defined and specified objectives for green chemistry experiments.

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