

## **TEACHERS' APPLICATION OF GREEN CHEMISTRY PRACTICES IN SENIOR SECONDARY SCHOOLS IN KWARA STATE, NIGERIA**

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### **Abstract**

Human activities have exposed the environment to a variety of harmful substances. Some of these substances are wastes from homes, schools, laboratories and industries, among others. Green chemistry is a practice in science that aims at generating and creating safe and non-toxic substances and energy, with a view to creating a safe environment to live in. This research focused on teachers' application of green chemistry practices as they have the fundamental role of educating and training future scientists. 210 chemistry teachers were purposively selected from both public and private secondary schools in Kwara Central Senatorial District, Kwara State, Nigeria. The research was a survey research. A questionnaire named 'Teachers' Application of Green Chemistry Practices Questionnaire (TAGCPQ)' was used to collect the data. Mean and percentage were used to answer the research questions while the research hypotheses were subjected to t-Test and Analysis of Variance (ANOVA). Findings from the study revealed that teachers' application of green chemistry practices was high (3.46 out of a maximum score of 4). There was a significant difference in the application of green chemistry practices among experienced, moderately experienced and less experienced teachers in favour of the experienced teachers. It was recommended that the experienced chemistry teachers should carry the less experienced teachers along in the practice of green chemistry and that the public schools should provide enabling environment that would give all teachers equal opportunity to practice what they have learnt.

**Keywords:** green chemistry, application, teachers' qualification, teachers' experience.

### **Introduction**

The environment has been badly polluted through many sources. Some of these sources are gaseous explosions, crude oil spillages, gas flaring, among others. These incidents release toxic gases into the environment of which greenhouse gases; carbon dioxide, methane and carcinogen benzene are prominent. It therefore becomes imperative to adopt and adhere to practices that will rescue our environment from further damage. Amanze-Nwachukwu (2008) as cited in Agbayewa, Oloruntegbe and Alake (2013) reported that 400 million tons of carbon dioxide, a greenhouse gas, is released per year in the Niger-Delta gas flaring. This, the study observed, is in addition to the pollution of water bodies from untreated effluent from chemical industries.

Nigeria's oil spillage alone contributes largely to environmental pollution. Importantly, with the recent pipeline sabotages in the Niger-Delta region, the entire environment has become badly polluted. Interestingly, science has increased human knowledge of the various adverse consequences of chemicals thereby resulting in the design of chemical products and the transformation process- green chemistry (Anastas & Beach, 2009, Agbayewa et al., 2013).

Green chemistry is the practice of science that relates to generating and creating safe, non-toxic, energy efficient and non-hazardous processes that deliver a concrete path towards solving today's environmental problems (Mazzali, Morin & Paquette, 2009). According to the United States Environmental Protection Agency (2015), green chemistry is a philosophy that applies to all topics of chemistry as it applies innovative and specific chemistry-related solutions to real-world environmental problems. Thus, there is need for the application of green chemistry practices in the classrooms and the laboratories by qualified and professionally experienced teachers as these teachers play vital roles in the training and the development of future scientists and the nation as a whole.

In many classrooms and laboratories, laboratory lessons and experiments seem to have remained the same for so many years. Most of these experiments involve the use of gases that are not safe in the environment and students often fall victims of these unfortunate situations (Monograph on Green Chemistry, 2014). Adedayo and Owolabi (2014) opined that harmful chemicals cause both local and systematic effects and that many laboratory instructors and students in Nigerian secondary schools are exposed to the dangers of thermal and chemical reactions. Therefore there is the need to take a critical look at this system of operation and integrate green chemistry practices in the classrooms and the laboratories.

Green chemistry knowledge can be applied in the classrooms and laboratories by the teachers. Green Heart Education (2015) suggested the following guidelines

for applying green chemistry practices in the classroom and the laboratory:

1. Learn and understand fully the twelve principles of green chemistry;
2. Get copies of curriculum mapping for planning classroom lessons and integrate such in lesson delivery;
3. Develop and maintain the sense of eagerness and chemical wonder in the students;
4. Make sure chemicals to be used for laboratory lessons are less hazardous to humans, living organisms and the entire ecosystem and are not persistent in the environment;
5. Design ways to increase safety in the laboratory, minimize the generation of waste both inside and outside the laboratory by learning the adverse effects of most of these chemicals and discussing their impact on the society;
6. Integrate lessons in basic toxicology- dose response, hazard/exposure paradigm with health related topics in the curriculum;
7. Always use the school resources like the school farm and water source when treating relevant topics in the classrooms;
8. Create a 'green chemistry club' that will sensitize the others of the need for a safer environment by sharing the visions and ideas of green chemistry through various educative programmes (p.5).

A teacher's academic qualification, experience and the type of school where he teaches could influence his application of the principles of green chemistry. The study therefore sought to find out if teachers understood the basic principles guiding the application of green chemistry in the classroom and in laboratory lessons and if they have been applying these principles in the classrooms and the laboratories.

### **Purpose of the Study**

The main purpose of this study was to find out teachers' application of green chemistry practices in senior secondary schools in Kwara State. Specifically, the study sought to find out:

1. chemistry teachers' application of green chemistry practices;
2. the influence of chemistry teachers' academic qualification on their application of green chemistry practices;
3. whether chemistry teachers' professional experience had influence on their application of green chemistry practices;
4. if school type on had influence on chemistry teachers' application of green chemistry practices.

### **Research Questions**

The following research questions were answered in this study:

1. What is the level of the chemistry teachers' application of green chemistry practices in their lessons?

2. How do chemistry teachers' academic qualifications influence their application of green chemistry?
3. Does the application of green chemistry practices by the teachers vary among experienced, moderately experienced and less experienced chemistry teachers?
4. Does school type have influence on chemistry teachers' application of green chemistry?

### **Research Hypotheses**

The following research hypotheses were tested at 0.05 level of significance:

HO<sub>1</sub>: There is no significant difference in the application of green chemistry practices by qualified and unqualified chemistry teachers;

HO<sub>2</sub>: There is no significant difference in the application of green chemistry practices by experienced, moderately experienced and less experienced teachers;

HO<sub>3</sub>: There is no significant difference in the application of green chemistry practices based on school type.

### **Research Method**

The population for the study was all the chemistry teachers in Kwara State. Two hundred and seventy (270) teachers were targeted for the research but a total of two hundred and ten (210) chemistry teachers successfully responded to the research instrument. This included 126 chemistry teachers from the public schools and 84 chemistry teachers from the private schools. This comprised chemistry teachers from both the public and private schools in Kwara Central Senatorial District comprising Asa, Ilorin East, Ilorin West, Ilorin South and Moro Local Government Areas. The Teachers' Application of Green Chemistry Practices Questionnaire (TAGCPQ) which contained twenty items on the application of green chemistry practices was used to collect the data. The instrument was adapted from the Reinhardt's (2011) guidebook on applying green chemistry principles to laboratory operations and Beyond Benign curriculum mapping for high school chemistry students. The TAGCPQ had response modes of Always (A), Occasionally (O), Rarely (R) and Not At All (N). Numerical values of 4, 3, 2 and 1 were assigned to the response modes. The Statistical Package for the Social Science (SPSS) version 20.0 was used for the analysis.

Letters of introduction were given to the principals of the schools on the first visits to the schools to seek their approval to engage the chemistry teachers in the study. The chemistry teachers were also intimated on the need to partake in the research through the informed consent forms. Subsequently, the instruments were administered to the chemistry teachers. Some of the filled copies of the questionnaire were collected the same day while others were collected at a later date as convenient for the respondents. The research questions were answered

using the mean and percentage while the hypotheses were analysed using t-Test and Analysis of Variance (ANOVA). Hypotheses 1 and 2 were tested with the t-Test and hypothesis 3 was tested using ANOVA, all at 0.05 level of significance.

### Data Analysis and Results

**Research Question 1.** What is the level of the chemistry teachers' application of green chemistry practices?

The grading format of the level of application of green chemistry practices is as follows:

Low level = 0 – 2.0

High level = 3.1 – 4.0

Average level = 2.1 – 3.0

Table 1 reveals the mean score of the level of the chemistry teachers' application of green chemistry. A mean of 3.46 was obtained. This implies that the level of application of green chemistry practices by the teachers was high.

Table 1: Level of the chemistry teachers' application of green chemistry

| Groups        | Cases included (%) | Cases not included (%) | Mean Total | SD Total |
|---------------|--------------------|------------------------|------------|----------|
| Qualification | 189(90)            | 21(10)                 | 3.46       | 0.45     |
| Experience    | 189(90)            | 21(10)                 |            |          |
| School type   | 210(0)             | 0(0)                   |            |          |

Key: Cases included - the number of respondents represented in the analysis based on qualification and experience.

Cases not included - represented those that were not represented in the analysis based on qualification and experience. These respondents did not fill in the appropriate sections on the Teachers' Professional Information Form.

**Research Question 2:** How do teachers' academic qualifications influence their application of green chemistry?

Table 2 indicates that the mean score of the qualified teachers is close to that of the unqualified teachers. The qualified teachers had a mean score of 3.48 while the unqualified teachers had a mean score of 3.39. This shows that teachers' academic qualification has little influence on chemistry teachers' application of green chemistry.

**Hypothesis 1 (H<sub>01</sub>):** There is no significant difference in the application of green chemistry practices by qualified and unqualified chemistry teachers.

The t-Test analysis presented on table 2 shows no statistically significant difference in the application of green chemistry by the unqualified and qualified

chemistry teachers,  $t(187) = 1.06$ ,  $p > 0.05$ . The unqualified teachers reported almost a similar application of green chemistry with the qualified teachers, ( $M = 3.39$ ,  $SD = 0.28$ ) and ( $M = 3.48$ ,  $SD = 0.49$ ) respectively. Therefore, the null hypothesis which states that there is no significant difference in the application of green chemistry by the unqualified and the qualified chemistry teachers was not rejected since the  $p$ -value (0.29) was greater than 0.05 level of significance.

**Table 2:** t-Test analysis presenting the application of green chemistry practices of unqualified and qualified chemistry teachers

| Groups               | N   | Mean | SD   | df  | t-Test | p-value | Decision                        |
|----------------------|-----|------|------|-----|--------|---------|---------------------------------|
| Unqualified teachers | 39  | 3.39 | 0.28 | 187 | 1.06   | 0.29    | HO <sub>1</sub><br>Not Rejected |
| Qualified teachers   | 150 | 3.48 | 0.49 |     |        |         |                                 |

$p > 0.05$ , Not Significant

**Research Question 3:** Does the application of green chemistry practices by the teachers vary among experienced, moderately experienced and less experienced chemistry teachers?

Table 3 reveals that the experienced teachers had the highest mean score of 3.65 while the moderately experienced teachers and the less experienced teachers had mean scores of 3.39 and 3.45 respectively. This means that the application of green chemistry practices vary among the experienced, moderately experienced and the less experienced chemistry teachers in favor of the experienced teachers.

**Hypothesis 2 (HO<sub>2</sub>):** There is no significant difference in the application of green chemistry practices by experienced, moderately experienced and less experienced teachers.

The ANOVA result on Table 3 revealed a statistically significant difference among the experienced teachers, the moderately experienced teachers and the less experienced teachers,  $F(2, 187) = 4.49$ ,  $p < 0.05$ .

**Table 3:** ANOVA analysis of the application of green chemistry practices among less experienced, moderately experienced and experienced chemistry teachers.

| Groups                 | N  | Mean | SD   | df    | p-value | F    | Decision                    |
|------------------------|----|------|------|-------|---------|------|-----------------------------|
| Less experienced       | 65 | 3.45 | 0.53 | 2,187 | 0.02    | 4.29 | HO <sub>2</sub><br>Rejected |
| Moderately experienced | 84 | 3.39 | 0.34 |       |         |      |                             |
| Experienced            | 40 | 3.65 | 0.47 |       |         |      |                             |

$p < 0.05$ , Significant

**Table 4:** The post-hoc Scheffe test showing the differences between the moderately experienced and the experienced teachers

| (I) Years of Teaching Experience | (J) Years of Teaching Experience | Mean Difference (I-J) | Std. Error | Sig. |
|----------------------------------|----------------------------------|-----------------------|------------|------|
| Below 5 years                    | 5 - 10 years                     | .04794                | .07480     | .815 |
|                                  | Above 10 years                   | -.21071               | .09436     | .086 |
| 5 - 10 years                     | Below 5 years                    | -.04794               | .07480     | .815 |
|                                  | Above 10 years                   | -.25866*              | .08910     | .016 |
| Above 10 years                   | Below 5 years                    | .21071                | .09436     | .086 |
|                                  | 5 - 10 years                     | .25866*               | .08910     | .016 |

The post-hoc Scheffe test on Table 4 revealed a statistically significant difference between the experienced teachers and the moderately experienced teachers (Mean Difference = 0.26). The test did not reveal any statistically significant difference between the experienced teachers ( $M = 3.65$ ,  $SD = 0.47$ ) and the less experienced teachers ( $M = 3.45$ ,  $SD = 0.53$ ) at 0.05 level of significance. Since the  $p$ -value (0.02) was less than 0.05, the null hypothesis is rejected.

**Research Question 4:** What influence does school type have on chemistry teachers' application of green chemistry?

Table 5 shows that the public school teachers had a lower mean score than the private school teachers. The public school teachers had a mean score of 3.41 while the private school teachers had a mean score of 3.55. This implies that school type influences the application of green chemistry practices.

**Hypothesis 3 ( $H_{O3}$ ):** There is no significant difference in the application of green chemistry practices based on school type.

The t-Test result on table 5 revealed a statistically significant difference in the application of green chemistry by the chemistry teachers in both the public and private school,  $t(208) = 2.03$ ,  $p < 0.05$ . The mean score of the chemistry teachers in the public schools ( $M = 3.41$ ,  $SD = 0.38$ ) is different from those of the teachers in the private schools ( $M = 3.55$ ,  $SD = 0.54$ ).

**Table 5:** t-Test analysis showing the influence of school type on chemistry teachers' application of green chemistry

| Groups          | N   | Mean | SD   | df  | t-Test | p-value | Decision             |
|-----------------|-----|------|------|-----|--------|---------|----------------------|
| Public schools  | 126 | 3.41 | 0.38 | 187 | -2.03  | 0.04    | $H_{O3}$<br>Rejected |
| Private schools | 84  | 3.55 | 0.54 |     |        |         |                      |

$p < 0.05$ , Significant

Since the  $p$ -value (0.04) is less than the level of significance of 0.05, the null

hypothesis which states that there is no significant difference in the application of green chemistry practices based on school type was rejected, meaning that there was a significant difference in the application of green chemistry practices in favor of teachers in the private schools.

### **Summary of Findings**

Based on the results obtained from the analyses, the findings are summarised as follows:

1. The level of application of green chemistry practices by the chemistry teachers in the classrooms and the laboratory was high. A mean score of 3.46 was obtained out of a maximum score of 4.0.
2. The mean score of the qualified teachers (3.48) was close to that of the unqualified teachers (3.39). This shows that teachers' academic qualification had little influence on chemistry teachers' application of green chemistry.
3. The experienced teachers had the highest mean score of 3.65 while the moderately experienced teachers and the less experienced teachers had mean scores of 3.39 and 3.45 respectively. This means that the application of green chemistry practices varied among the experienced, moderately experienced and the less experienced chemistry teachers in favor of the experienced teachers.
4. The public school teachers had a lower mean score (3.41) than the private school teachers (3.55). This implies that school type influenced the application of green chemistry practices.
5. There was no significant difference in the application of green chemistry practices between the qualified and the unqualified chemistry teachers,  $t(187) = 1.06$ ,  $p > 0.05$ . Therefore hypothesis 1 was not rejected.
6. The application of green chemistry varied significantly among experienced, moderately experienced and the less experienced chemistry teachers,  $F(2,187) = 4.29$ ,  $p < 0.05$ . The post-hoc Scheffe test also revealed a significant difference between the experienced group and the moderately experienced group.
7. School type had a significant influence on the application of green chemistry practices,  $t(208) = 2.03$ ,  $p < 0.05$  in favour of the private school teachers ( $M = 3.55$ ) Therefore, hypothesis 3 was rejected.

### **Discussion of Findings**

Empirical studies in the area of teachers' application of green chemistry practices are rare. Hence, there are very few studies to compare the findings of this study with along that line. However, other studies have examined the variables of teacher qualification, experience and school type which have been of interest in this study.

The results obtained from the analyses of the obtained data reveal that the level of teachers' application of green chemistry practices was high. The implication

of this finding is that the environment is not likely to be polluted with chemical wastes from school laboratories. Chemistry students, their teachers and other people in the school environment are not likely to be exposed to the hazards of improper disposal of chemical wastes from the laboratories and this in effect, would contribute to the overall health of the environment.

Expectedly, teachers' qualification should influence their performance as teachers, which normally should transform into better students' performance. This is affirmed by Fakeye (2012) in a study conducted on teachers' qualification and subject mastery in which he found out that teachers' teaching qualification had a significant relative contribution to students' academic achievement in English Language. In another report, Abe (2014) showed that a significant difference existed in the performances of students taught by professionally qualified teachers and non-professional teachers.

In this study, no significant difference was found in the application of green chemistry practices between the qualified and the unqualified teachers. It should still be noted however, that the mean score of qualified teachers (3.48) was higher than that of the unqualified teachers (3.39). The difference here is that professionally qualified teachers are distinguished from non-professionally qualified teachers in terms of prior training in pedagogy. However, green chemistry practices are enshrined in the core chemistry area which both categories of teachers were exposed to in training. Hence, the two categories of teachers are nearly at the same level and are actually not expected to differ significantly in applying green chemistry practices.

However, the results obtained from the ANOVA analysis on the application of green chemistry practices among experienced teachers, moderately experienced teachers and the less experienced teachers revealed a significant difference between the experienced group and the moderately experienced as captured by the post-hoc test. Even though, the difference between the mean of the less experienced and the experienced was found to be non-significant, it was still in favour of the experienced ( $M = 3.45$  and  $3.65$  respectively). These results lays credence to the findings of Dial (2008), Ladd (2008), Akinsolu (2010), Ladd and Sorrenson (2014), and Ewetan and Ewetan (2015), all of whom reported that teachers' number of years of teaching experience significantly influenced their teaching performance positively as reflected in their students' academic performances across school subjects. This finding of this study further amplifies the importance of experience in teaching.

Finally, the findings showed that school type influenced the application of green chemistry practices significantly. The private school teachers had a higher mean score on the application of green chemistry practices than the public school teachers. This better posture on the part of the private school teachers is in line with an earlier finding of a study by Choy (1997) which revealed that private school teachers had better working conditions and were more satisfied with these

conditions than the public school teachers. In this case, the private school teachers could have been more motivated and this could be responsible for their better output.

Many more recent studies on private and public schools have put the private schools above the public schools on many variables. For instance, Olasehinde and Olatoye (2014) did a comparative study of public and private senior secondary school students' science achievement in Katsina State, Nigeria. The results showed that private school students performed significantly better than their counterparts in public schools. A similar result was reported by Shabbir, Wei, Fu, Chong, Marwat, Nabi and Ahmed (2014) in a study that compared the performance, and effectiveness of government and private primary schools in rural areas of Azad Jammu and Kashmir. This study therefore lays credence to previous submissions that place private schools above public schools, and in this particular context, in the area of teachers' application of green chemistry practices.

So also, Frenette and Chan (2015) also reported from their study that at age 15, private high school students scored significantly higher than public high school students on reading, mathematics, and science assessments, and also had higher levels of educational attainment by age 23. Similarly, Sherafat and Murthy (2016) sought to find out whether a difference existed in public and private school students' critical thinking and study habits. Their findings revealed that private school students had better critical thinking ability and study habits than their counterparts in private schools. Their findings were assumed to be traceable to the enabling environment the teachers in private schools were exposed to as compared to their counterparts in public schools.

### **Conclusion**

The results showed that the level of application of green chemistry practices by the chemistry teachers was high. Furthermore, academic qualification did not influence the application of green chemistry practices by the chemistry teachers significantly. However, teachers' years of experience and school type had significant influences on the application of green chemistry practices.

### **Recommendations**

Based on the findings of the study, the following recommendations are made:

1. The experienced chemistry teachers should carry the less experienced teachers along in the practice of green chemistry. They should provide appropriate mentorship for their junior colleagues in the area of green chemistry practice.
2. The public schools should provide enabling environment that would give all teachers equal opportunity to practice what they have learnt and what they know.

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