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EXPLORING TEACHERS' KNOWLEDGE AND PRACTICE OF GREEN CHEMISTRY PRINCIPLES IN THE SCHOOLS SOUTH-WEST NIGERIA

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Abstract

Purpose: One major way to curb human actions that are averse to reduction of greenhouse effects is through the practice of green chemistry principles. This study explored the role of gender and experience knowledge of teachers on the practice of green chemistry principles among teachers in South-west Nigeria. It examines the differences in knowledge and practices among teachers in universities, colleges of education, and secondary schools, as well as any potential gender differences. **Design/methodology/approach:** The study employs the ecological systems theory as a theoretical framework to understand the role of gender and teachers' years of experience on the practice of green chemistry. A quantitative research method with a cross-sectional descriptive design is used, and data is collected through a self-developed structured questionnaire from 158 teachers. **Findings:** a significant difference was found in the practice of green chemistry among teachers based on school type. Also, the findings showed that there was no significance difference in teachers' knowledge of green chemistry principles on the basis of teachers' gender and years of experienced in schools in South-west, Nigeria **Practical implications:** The study identified the need for inclusive training for teachers to eliminate differences found in the practice of green chemistry principles in schools. Teachers' adequate knowledge and practice of green chemistry will foster students' knowledge and practice of green chemistry and the society at large. **Originality/value:** This study provides valuable insights for designing interventions to enhance the incorporation of green chemistry principles in chemistry education in Southern Nigeria.

Keyboards: Green Chemistry Education, School Type, Teachers' Gender, Knowledge, Experience

INTRODUCTION

The need for environmental sustainability is a pressing global concern, and the role of education in fostering sustainable practices cannot be overstated (Pegalajar-palomino et al., 2021). Nigeria, like many other countries, faces significant environmental challenges. These challenges range from deforestation, pollution, indiscriminate waste dump, depletion of natural resources, to the effects of climate change (Dick & Nwekeala, 2021). Achieving environmental sustainability is a shared global goal and education plays a pivotal role in raising awareness and fostering sustainable practices (Ghazali & Yahaya, 2022). In the Nigerian context, it is essential to understand how teachers' knowledge and practices can contribute to this endeavor.

Green chemistry is an emerging field that emphasizes the design and application of chemical products and processes that reuse and recycle waste, reduce or eliminate the use and generation of hazardous substances. Integrating green chemistry principles into education do not only equips students with the knowledge and skills needed for sustainable practices but also fosters a mindset that can positively impact the environment (Chen et al., 2020). Understanding how teachers in the region of Southern Nigeria engage with green chemistry is vital for developing

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effective strategies to incorporate these principles into the curriculum towards enhancing students' knowledge and practice of green chemistry and having an environment suitable for living.

Teachers serve as key agents in shaping students' understanding of the world, including their awareness of environmental issues and sustainable practices (Listyarini et al., 2019). Thus, the knowledge and practices of teachers are central to the success of environmental education (Koskela, 2021). Teachers' knowledge of green chemistry principles and their ability to incorporate them into teaching (Hurst et al., 2019 can significantly influence the next generation's environmental consciousness and actions. In Nigeria, where environmental issues, including waste management, are increasingly concerned, teachers who integrate green chemistry and sustainability education into their teaching practices can significantly contribute to raising awareness and consciousness within the society. These teachers play a vital role in creating a more environmentally conscious and responsible citizenry by equipping students with the knowledge, skills, and values necessary for sustainable living.

Within this context, the study titled "Exploring Teachers' Knowledge and Practice of Green Chemistry Principles in South west Nigeria: " seeks to investigate and shed light on the critical nexus between teacher knowledge, pedagogical practices, and the integration of green chemistry principles in the educational landscape region of Southern Nigeria . The study considers three crucial factors: school category, gender and teaching experience. School category has great impact on the general society, gender dynamics can impact how teachers approach green chemistry education, as societal expectations and norms may influence their roles and teaching styles. Moreover, teaching experience can shape pedagogical strategies (Hurst, 2019) and the adoption of innovative teaching methods. Understanding how these variables intersect with green chemistry education is fundamental to developing targeted interventions for enhancing environmental sustainability in education.

Purpose of the study

The specific purposes of the study are to determine:

i) The extent of teachers' awareness of green chemistry principles in Southern Nigeria?

ii) If there is difference in the practice of green chemistry principles in Southern Nigeria among teachers based on gender?

iii) If there is difference in the practice of green chemistry principles among teachers based on school category (Universities, Colleges of Education and Secondary Schools)?

iv) The relationship between knowledge and practices of green chemistry principles among teachers based on teaching experience (Universities, Colleges of Education and Secondary Schools)?

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Research QX uestions

i) To what extent do teachers in Southern Nigeria region are aware of green chemistry principles?

ii) Is there a difference in knowledge and practices of green chemistry principles among teachers based on gender?

iii) Is there any difference in the practices of green chemistry principles among teachers based on school category, Universities, Colleges of Education and Secondary Schools?

iv) Is there any difference in the knowledge and practices of green chemistry principles among experienced teachers in the Universities, Colleges of Education, Secondary Schools and their counterparts who are not experienced?

LITERATURE REVIEW

Theoretical Framework

Ecological Systems Theory, proposed by Urie Bronfenbrenner (Costello, 2020), offers a valuable framework for understanding the intricate factors that influence individuals' behavior within their ecological contexts. It represents three fields ecology, social sciences and psychology (Crawford, 2020). When applied to the study of teachers' practice of green chemistry principles in Southern Nigeria, this theory provides a comprehensive perspective. Within the microsystem, which encompasses immediate environments like schools and classrooms, the study explores the impact of gender, school type and teaching experience on teachers' practice of green chemistry (Costello, 2020). Gender expectations, school type and teaching expertise operate within this microsystem, influencing teachers' behavior and educational practices. The microsystem dimension examines how factors in one microsystem, such as the classroom, interact with and affect teachers' roles and practices in another (Costello, 2020), like the broader educational context in Southern Nigeria. The exosystem analyzes how external settings, including societal norms, influence green chemistry practices (Crawford, 2020). It considers the indirect effects of gender norms and societal expectations on teachers' adoption of green chemistry principles, as well as the influence of educational policies shaped by societal norms. The macrosystem delves into the broader cultural, societal, and historical context, shedding light on how cultural and gender norms, educational history, and societal values in Southern Nigeria shape teachers' approaches to green chemistry education. Finally, the chronosystem dimension explores how changes and developments over time impact teachers' practices. It offers insights into the evolution of gender roles and teaching practices related to green chemistry in Southern Nigeria, highlighting the dynamic nature of these influences.

This theoretical foundation, grounded in the Ecological Systems Theory, enables researchers to analyze the multifaceted interplay of gender and teaching experience across various ecological layers. It offers a deep understanding of the complexities that impact teachers' practice of green chemistry principles in Southern Nigeria. By considering personal,

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environmental, cultural, and historical (experience) factors, this approach has the potential to inform more effective strategies for promoting the integration of green chemistry principles in the region, ultimately contributing to the enhancement of science education in a sustainable and equitable manner (Bronfenbrenner, 1979).

Overview of Green Chemistry Principles and their Application in Education

Green chemistry is specially designed to ensure that chemical science and manufacturing in such a way that is sustainable, safe, and non-polluting (Mitarlis et al., 2017). As an essential part of chemistry education (Juanjuan & Shengli, 2018), green chemistry promotes an environmentally benign paradigm (Mammino, 2015), helps to prevent accidents, gives security assurance, and ensures sustainability (PAS). Therefore, PAS becomes the summary of twelve principles upon which green chemistry is anchored on. Green chemistry emphasizes the comprehensive understanding of avoiding things that can destroy the environment. The University of Scranton had in 1996 launched green chemistry as part of its environmental chemistry curriculum (Juanjuan & Shengli, 2018). The University of Oregon's Chemistry Department did the same by embarking on a project in 1997 to modernize its conventional organic chemistry laboratory curriculum by embracing the emerging concepts and principles of green chemistry (Hutchison, 2019). The integration of Green Chemistry principles within the small-scale chemistry (SSC) approach is evident through waste prevention, conducting safer chemistry experiments to prevent accidents, and using renewable feedstock (Listyarini et al., 2019). It has been noted that chemistry as a subject is full of dangerous and risky experiments (Wahyuningsih et al., 2018). A learning approach can be adopted to achieve a high level of awareness and develop skills that can be used to solve the problem (Listyarini, 2019). Since green chemistry is targeted at preventing chemical hazards (Owoyem. et al, 2020), the onus is on the policymakers and educational planners, including teachers, to devise the best approach to creating awareness among the learners.

Previous Studies on Teachers' Practice of Green Chemistry Principles

Teachers' role in achieving green chemistry goals is tremendous and cannot be emphasized. Teachers are mentors to learners, who prepare the learners with adequate knowledge and skills for future living through teaching and practices. Hence, teachers are indispensable, and a nation cannot grow beyond the level of its teachers (Dada et al., 2018). Education stakeholders have agreed on that in the last four decades (Dada et al., 2018). According to Hutchison (2019), adopting curricular change is the first step in modelling teachers' capacity building. As a subject full of risks and danger, chemistry requires a curriculum that will contain the development of laboratory safety skills and consciousness (Wahyuningsih et al., 2018). In the bid to actualize a danger-free chemistry classroom, the University of Oregon's Chemistry Department embarked on a project in 1997 to modernize its conventional organic chemistry laboratory curriculum by embracing the emerging concepts and principles of green chemistry (Hutchison, 2019). In addition, chemistry teachers are responsible for meaningfully incorporating the United Nations Sustainable Development Goals into the curriculum at all levels of education (Eaton et al., 2019). Meiai et al 2020) emphasized that integration of green chemistry teaching with sustainable education promoted green chemistry learning by fostering environmental

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consciousness and behavioral change and cognitive process in a sustainable direction. Teachers, therefore, need a comprehensive knowledge of the art and science of green chemistry curricula. Hurst et al. (2019) suggest that teachers can benefit from various training programmes on curricula sustainability, like the one hosted by the University of Cordoba and Spain, which provides them with a working knowledge of the impact of human activities and nature on the environment. Teachers' knowledge of environmental sustainability will regulate individual environmental action, which is incremental (Debrah et al., 2021).

Dodson et al. (2015) suggested that schools should ensure that teaching materials used to teach chemistry should incorporate industrial case studies and their relevance to green chemistry as a course. The finding implies that associations with businesses will be necessary for schools. According to Wihardjo et al. (2017), a person's level of knowledge typically determines the extent of his concern for environmental issues. As a result, this is essential to environmental sustainability. One of the findings of the study conducted by Ganapathy et al. (2018) indicated that the effort to increase students' awareness of green chemistry is ongoing globally; the critical sustainability concepts still need to be included in most chemistry curricula. When students are fully informed, they will be prepared to analyze, interpret, assess, and make informed decisions about their environment (Kidman & Casinade, 2019).

Gaps and Challenges in Teachers' Practice of Green Chemistry Principles in Nigeria

Like other places worldwide where green chemistry principles and teachers' practice face challenges (Hurst, 2019), integrating green chemistry into the curriculum and classroom instruction in Nigeria has been a big challenge. These challenges include limited awareness and understanding among teachers, lack of training and professional development opportunities, inadequate resources and infrastructure, curriculum limitations, limited support from educational institutions and policymakers, and socio-cultural factors (Owoyemi & Adesina, 2020, 2021).

The study conducted by Owoyemi and Adesina (2021), Oloruntegbe & Alake (2021) revealed that both male and female teachers in Southern Nigeria need more knowledge and awareness of green chemistry principles, which hampers their ability to incorporate them into their lessons effectively. Additionally, lacking targeted training programs focused on green chemistry prevents teachers from acquiring the necessary skills and knowledge for integration. In Malaysia, a study conducted by Taha et al. (2019) revealed that green chemistry is new to teachers to the extent that many of them cannot say anything about it, let alone practice it. This lack of knowledge of green chemistry has made many teachers mistake it for environmental chemistry (Taha et al., 2019). More resources and infrastructure, such as laboratory facilities and chemicals, pose further obstacles to implementing green chemistry practices. The existing curriculum may need to adequately address green chemistry principles, resulting in a gap in classroom content. Furthermore, limited support from educational institutions and policymakers and socio-cultural factors, such as resistance to change and traditional teaching methods, impede the successful adoption of green chemistry principles (Taha et al., 2020; Mason, 2020).

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Addressing these gaps and challenges requires a multi-faceted approach. Developing targeted teacher training and professional development programs focused on green chemistry principles is essential. Improving the availability of resources and infrastructure in schools is necessary to support green chemistry practices. Curriculum reforms should be implemented to incorporate green chemistry principles into the curriculum explicitly. For instance, in the sixth Malaysian national plan, environmental consideration was integrated (Taha et al., 2019) to create environmental sustainability consciousness in the citizens. Strong support from educational institutions and policymakers is crucial for promoting and facilitating the integration of green chemistry. Efforts should also be made to raise awareness and promote the benefits of green chemistry principles among students, parents, and the wider community (Hurst et al., 2019; Owoyemi & Adesina, 2020). By addressing these challenges, teachers in Southern Nigeria can effectively integrate green chemistry principles into their teaching practices. This integration will contribute to sustainable and environmentally conscious education, fostering a generation of students who are knowledgeable and committed to sustainable practices (Debrah et al., 2021; Yates et al., 2019).

The following hypotheses, therefore, emerged from the reviewed literature:

H01: There is no significant difference practice of green chemistry principles among teachers based on gender?

H02: There is no significant difference in the practice of green chemistry principles among teachers based on school category, Universities, Colleges of Education and Secondary Schools?

H03: There is no significant difference in the practices of green chemistry principles among teachers in the Universities, Colleges of Education and Secondary Schools based on experience?

METHODOLOGY

Research Design

This study adopted a quantitative research method of cross-sectional descriptive design (Zangirolami-raimundo & Oliveira, 2018). Quantitative research is an empirical approach that focuses on the objective measurement and analysis of numerical data (Mugenda & Mugenda, 2003). It involves collecting data in a structured manner and using statistical methods to analyze and interpret the data (Creswell & Creswell, 2018; Gounder, 2012). This method is useful for studying relationships, patterns, and trends, as well as generalizing about a larger population. On the other hand, the cross-sectional design is a type of research design where data is collected from a sample of individuals or subjects at a specific point in time (Zangirolami-raimundo & Oliveira, 2018). It provides a snapshot of the variables of interest at that moment, allowing researchers to describe the characteristics among variables this design is commonly used to gather information about the prevalence, distribution, and associations of variables in a population.

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Sampling technique and participants

This study adopted a multi-stage sampling technique to select 158 teachers in senior secondary schools, colleges of education and University from six states in the Southwestern Nigeria region. The study adopted a stratified sampling technique to group the six Southwestern states into the industrialized and non-industrialized. Thereafter, a simple random sampling technique was used to select two senior secondary schools, one college of education and one university from each state. On the other hand, the purposive sampling technique was used in the selection of 81 senior secondary school chemistry teachers, 39 chemistry lecturers in colleges of education and 38 chemistry lecturers in universities of the selected schools.

Data collection methods

A self-developed structured questionnaire tagged Green Chemistry Teacher Questionnaire (GCTQ) was used to collect data. The questionnaire is sectionalized into two, A and B. Section A contains demographic information of the participants. In contrast, section B contains questions on the two constructs, knowledge, and practice of green chemistry principles among teachers. The instrument was further subjected to a reliability test to determine its consistency for the purpose for which it was developed. The instrument, therefore, yielded 0.76 Cronbach's alpha coefficient reliability.

Ethical considerations

The issue of ethical considerations in research is held with high levels of importance, especially when the study involves human beings ((WMA), 2013). Thus, the informed consent of all the participants was sought, and they were duly informed of the purpose of the study (Dooly et al., 2017). The researcher assured the participants of their anonymity and confidentiality of the information provided. They were assured that the information provided would be used only for research, and they approved.

Data analysis procedures

The data elicited from the participants were subjected to initial screening to determine the missing data using SPSS (Statistical Packages for Social Sciences) IBM version 29. Afterwards, the demographic information of the participants was analysed descriptively using frequency count and percentage. The hypothesis one was analysed with independent t-test, while hypotheses two and were tested with two-way Analysis of Variance (ANOVA) and Pearson Product Moment Correlation (PPMC) respectively with the aid of SPSS software version 29.0 at 0.05 significant level.

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RESULTS

Table 1 presents the demographic information of the participants in the study. The table provides information on four key variables: Gender, Academic Qualification, Years of Experience, and School Category. This data is presented in terms of frequency and percentage to give a clear overview of the distribution of participants across these variables.

As shown in Table 1, the participants were evenly distributed in terms of gender, with 79 participants (50%) being male and 79 participants (50%) being female. Regarding the participants' qualifications, the majority held a Bachelor's degree (Bsc/B.Ed) with 61 participants, accounting for 38.6% of the sample. The next most common qualification was a Master's degree (Msc/M.Ed), with 53 participants, representing 33.5% of the sample. The smallest group in terms of qualification was those with a Ph.D., comprising 44 participants, or 27.8% of the total sample.

Table 1: Demographic Information of the Participants

Variable		Frequency	Percentage (%)
Gender	Male	79	50
	Female	79	50
Qualification	B.Sc. /B.Ed.	61	38.6
	M.Sc / M.Ed.	53	33.5
	PhD	44	27.8
Years of Experience	0 -5 years	60	38.0
	6 - 10 years	57	36.1
	11 years and above	41	25.9
School Category	Secondary	81	51.3
	College of Education	39	24.7
	University	38	24.1

In terms of years of experience, the majority of participants, 60 individuals (38.0%), had 0 to 5 years of experience, while 57 participants (36.1%) had 6 to 10 years of experience. A smaller group, 41 participants (25.9%), had 11 years and above of experience. Finally, the participants were distributed across different school types, with 81 participants (51.3%) belonging to secondary schools, 39 participants (24.7%) associated with colleges of education, and 38 participants (24.1%) affiliated with universities.

Table 2: Awareness of green chemistry principles

Variable		Frequency	Percentage
Awareness	Not aware	0	0.0
	Moderately aware	58	36.7
	Aware	100	63.3

Awareness of green chemistry principles among the participants was measured on a three-point scale: "Not aware," "Moderately aware," and "Aware." The data as shown in table 2 reveals that most participants fell into the "Aware" category, with 100 individuals, representing 63.3% of the sample. A significant portion of the participants also fell into the "Moderately aware" category, with 58 individuals, making up 36.7% of the sample. Surprisingly, no participants

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reported being "Not aware" of green chemistry principles, indicating that there was a high level of general awareness among the study's participants.

This finding suggests that a substantial portion of the surveyed individuals were either moderately or fully aware of green chemistry principles. This high level of awareness may have implications for the study's exploration of the teachers' actual implementation of green chemistry practices in their teaching, as it suggests that the knowledge base for green chemistry is relatively strong among the surveyed participants.

H01: there is no significant difference in green chemistry practices based on teachers' gender.

Table 3: Difference in Green Chemistry Practices Based on Teachers' Gender

	Gender	N	Mean	SD	P	DF	t	MD	F	Eta^2
Practices	Male	79	3.58	.448	.001	156	-3.260	1.89	13.297	.30
	Female	79	3.76	.251						

Table 3 presents the results of the independent t-test comparing green chemistry practices between male and female teachers. Male teachers (N = 79) had a mean practice score of 3.58 (SD = 0.448), while female teachers (N = 79) had a slightly higher mean practice score of 3.76 (SD = 0.251). The results of the t-test indicate a statistically significant difference in green chemistry practices between male and female teachers (t (156) = -3.260, p = .001). The mean difference (MD) between the two groups was 1.89, with female teachers showing a higher mean practice score compared to male teachers. Further, the analysis of variance (ANOVA) revealed a significant main effect of gender on green chemistry practices, as indicated by the F-statistic (F = 13.297, p < .001). The effect size, measured by Eta², was .3, suggesting that gender accounts for a substantial proportion of the variance in green chemistry practices. In summary, the results suggest that female teachers, on average, have significantly higher green chemistry practices compared to their male counterparts. The effect of gender on green chemistry practices is statistically significant and accounts for a substantial portion of the variance. These findings imply that gender plays a notable role in influencing the implementation of green chemistry principles among teachers in the study, with female teachers exhibiting stronger engagement in these practices.

H02: There is no significant difference in teachers' knowledge of green chemistry principles based on teachers' gender and years of experiences.

In Table 4, descriptive statistics for the dependent variable "Knowledge of green chemistry among teachers" are presented, with a focus on the influence of two factors: Factor A, which is gender (Male or Female), and Factor B, which represents the years of experience (0-5 years, 6-10 years, and 11 years and above). For male teachers, the mean knowledge score for those with 0-5 years of experience was 3.7591, with a standard deviation of .35276. Teachers with 6-10 years of experience had a mean knowledge score of 3.7056 and a standard deviation of .28380. Lastly, teachers with 11 years and above of experience had a mean knowledge score of 3.6762, with a standard deviation of .44934. The overall mean knowledge score for male teachers across all experience levels was 3.7127, with a standard deviation of .34986. A total of 79 male teachers were included in this analysis.

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Table 4: Descriptive Statistics for dependent Variable

Factor A	Factor B	Mean	Std. Deviation	N
Male	0 – 5 years	3.7591	.35276	22
	6 – 10 years	3.7056	.28380	36
	11 years and above	3.6762	.44934	21
	Total	3.7127	.34986	79
Female	0 – 5 years	3.7342	.28878	38
	6 – 10 years	3.7857	.17688	21
	11 years and above	3.8300	.17800	20
	Total	3.7722	.23855	79
Total	0 – 5 years	3.7433	.31102	60
	6 – 10 years	3.7351	.25106	57
	11 years and above	3.7512	.34937	41
	Total	3.7424	.29996	158

Note: Factor A = Gender; Factor B = Years of Experience

For female teachers, the mean knowledge score for those with 0-5 years of experience was 3.7342, with a standard deviation of .28878. Teachers with 6-10 years of experience had a mean knowledge score of 3.7857 and a standard deviation of .17688. Those with 11 years and above of experience had a mean knowledge score of 3.8300, with a standard deviation of .17800. The overall mean knowledge score for female teachers across all experience levels was 3.7722, with a standard deviation of .23855. A total of 79 female teachers were included in this analysis. When considering all teachers regardless of gender, those with 0-5 years of experience had a mean knowledge score of 3.7433, with a standard deviation of .31102. Teachers with 6-10 years of experience had a mean knowledge score of 3.7351 and a standard deviation of .25106. Teachers with 11 years and above of experience had a mean knowledge score of 3.7512, with a standard deviation of .34937. The overall mean knowledge score for all teachers across all experience levels was 3.7424, with a standard deviation of .29996. This analysis involved a total of 158 teachers.

Table 5: Differences in Teachers' Knowledge of green chemistry based on Years of Experience and gender.

Tests of Between-Subjects Effects						
Dependent Variable: Knowledge						
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	.342[a]	5	.068	.755	.583	.024
Intercept	2066.433	1	2066.433	22788.115	<.001	.993
Gender	.179	1	.179	1.970	.163	.013
Years of experience	.001	2	.001	.008	.992	.000
Gender * Years of experience	.196	2	.098	1.080	.342	.014
Error	13.783	152	.091			
Total	2227.010	158				
Corrected Total	14.126	157				
a. R Squared = .024 (Adjusted R Squared = -.008)						

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Table 5 presents the results of an analysis of variance (ANOVA) examining the differences in teachers' knowledge of green chemistry based on their years of experience and gender. The dependent variable is "Knowledge".

The corrected model was statistically significant, $F(5, 152) = 0.755$, $p = 0.583$, indicating that there is no significant difference in teachers' knowledge of green chemistry based on years of experience and gender. The partial eta squared value ($\eta^2 = 0.024$) suggests that only a small proportion of the variance in knowledge can be attributed to the independent variables.

Specifically, the main effects for gender and years of experience were not statistically significant ($p > 0.05$), with $F(1, 152) = 1.970$ for gender and $F(2, 152) = 0.008$ for years of experience. Additionally, the interaction between gender and years of experience was not statistically significant, $F(2, 152) = 1.080$, $p = 0.342$.

The intercept was highly significant, indicating that there is a significant difference in teachers' knowledge overall. However, the adjusted R-squared value (-0.008) suggests that the model does not explain much of the variance in teachers' knowledge. In summary, the results indicate that there are no significant differences in teachers' knowledge of green chemistry based on years of experience and gender, as none of the main effects or interaction effects were statistically significant.

H03: There is no significance difference in the knowledge and practices of green chemistry principles among teachers based on educational institution level.

Table 6 presents the correlation between teachers' knowledge and practices of green chemistry in Southwest Nigeria region. The table reveals a significant positive relationship between these two variables.

Table 6: Relationship between teachers' Knowledge and practices of green chemistry in Southwest Nigeria

Correlations			
		Practices	Knowledge
Practices	Pearson Correlation	1	.490**
	Sig. (2-tailed)		<.001
	N	158	158
Knowledge	Pearson Correlation	.490**	1
	Sig. (2-tailed)	<.001	
	N	158	158
**. Correlation is significant at the 0.01 level (2-tailed).			

The Pearson correlation coefficient for the relationship between teachers' practices and their knowledge of green chemistry is $r = 0.490$ ($p < 0.01$, two-tailed), indicating a strong positive association. This suggests that as teachers' knowledge of green chemistry increases, their engagement in green chemistry practices also tends to increase.

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DISCUSSION

This study investigated the knowledge of green chemistry principles and its practices among teachers in senior secondary school, colleges of education and universities in Southwest Nigeria region. The study delved into Knowledge and practice of green chemistry with a particular focus on how gender and teaching experience played a role in these different educational settings. Notably, the research revealed a substantial disparity in the adoption and implementation of green chemistry practices among teachers across these three educational levels based on their awareness, gender and teaching experience.

The finding underscores the influence of gender on the incorporation of green chemistry principles into the teaching and learning process within various educational institutions. Interestingly, the result of this study corroborates the outcomes of a prior research investigation conducted by (Owoyemi & Moju, 2020).

Owoyemi and Moju's study similarly identified gender-related differences in the practice of green chemistry within educational settings. These parallel findings highlight the consistent influence of gender on the adoption of green chemistry practices and emphasize its relevance as a crucial factor that must be considered in efforts to promote and integrate green chemistry principles within the educational landscape.

The alignment between these two studies suggests the need for targeted strategies to address gender-related disparities in the practice of green chemistry, particularly in senior secondary schools, colleges of education, and universities. Understanding and addressing these differences can contribute to more effective and equitable approaches in promoting green chemistry education and sustainability initiatives across diverse educational contexts.

Similarly, the result of the study shows that teachers have high knowledge of green chemistry principles which is the foundation for the practice of green chemistry for environmental sustainability. The outcome established that majority of the participants fell between highly aware and moderately aware participants, while none of them has zero knowledge of green chemistry principles. This finding is in congruence with the study conducted in vocational schools in Indonesia that showed that half of the teachers had knowledge to be integrated into the teaching and learning of green chemistry (Alekseev, 2018).

Similarly, Owoyemi and Adesina (2020) found that chemistry teachers have moderate knowledge of green chemistry. In fact, environmental literacy was rated as an important component of the 21st century achievement (Mitarlis et al., 2017). In the same vein Wihardjo et al. (2017) found that green school knowledge influences level of environmental awareness. Those with lower green school knowledge have low awareness of their environment and vice-versa (Wihardjo et al., 2017) need to boost their knowledge. The school management, educational planners and government need to join hands together in providing refresher trainings to up skill the current chemistry teachers (Yates et al., 2019) at all levels of education and prepare the future teachers.

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Furthermore, no significant difference was found in the practice of green chemistry principles between male teachers/lecturers and their female counterparts in the university. This implies that gender of teacher in universities is not a perquisite for the practice of green chemistry principles to sustain the environment and protect it from any human endeavour that might be dangerous to the environment. The reason for this gender-neutral finding could be because environmental sustainability is the duty of all, irrespective of individual gender, race, colour and social class. This finding disagrees with Owoyemi and Adesina (2021) who reported a significant difference between male and female teachers. They explained further that, male teachers were better in the understanding of green chemistry than their female counterpart.

In this study, an intriguing discovery emerged, revealing a substantial connection between teachers' understanding of green chemistry principles and the actual implementation of green chemistry practices within the Nigerian educational context. There is mixed finding on the previous studies on this finding. While this disagrees with Carangue et al. (2021) who found that teachers knowledge did not affect the integration of green chemistry in the teaching and learning in the classrooms, Ghazali and Yahaya (2022)found a low positive significant relationship between awareness of green and practices among pre-service teachers in Malaysia.

The incongruity between the current study's results and the conclusions of Carangue et al. is noteworthy and invites further exploration. While the exact reasons for this discrepancy remain to be elucidated, it underscores the complexity of the relationship between teachers' knowledge and the practical implementation of green chemistry principles in different educational settings. This discrepancy in findings underscores the complex and context-dependent nature of the relationship between teacher knowledge and the implementation of innovative educational approaches like green chemistry. It may be influenced by various factors, such as the availability of resources, the curriculum framework, or the level of teacher training, which can differ significantly between different educational settings. This divergence in results also highlights the importance of conducting region-specific research to better understand how educational practices are influenced by teacher knowledge and context, ultimately informing more effective strategies for curriculum development and teacher training in the field of green chemistry.

CONCLUSION

The study has shown that a significant difference existence in the practices of green chemistry principles among teachers in Southwest, Nigeria. However, teachers' experience and gender did not have significant effect on teacher's knowledge of green chemistry among teachers in senior secondary schools, colleges of education, and universities. Although, there was a significant awareness of green chemistry principles among teachers in the studied educational institutions in south west, Nigeria. It was also established in the study that a positive significance relationship existed between knowledge and practice of green chemistry in senior secondary schools, colleges of education, and universities. This implies that the role of knowledge and practices of green chemistry cannot be underrated in environmental sustainability in Nigeria.

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Recommendations

This study recommends the following based on the findings.

i) Special training should be organized for all chemistry teachers at all levels of education on the ideals and ways of integrating green chemistry into the traditional curriculum of chemistry. As a matter of importance, the training should be made mandatory.

ii) Both the government and school managers should give the required support and resources for teachers to incorporate green chemistry principles effectively.

iii) Collaboration between educational and environmental stakeholders to facilitate the practice of green chemistry principles should be employed.

iv) There should be continuous advocacy programmes within the schools to increase the knowledge and practice of green chemistry principles among the teachers and the students.

v) Educational stakeholders should consider translating cultural ethics that support environmental sustainability into practice.

Limitations of the Study

The sample size is very small and can limit the generalizability of the findings.

Therefore, further research in related areas of green chemistry should be conducted. A comparative study involving the southern and northern states in Nigeria may be conducted. Future studies can make use of mixed method to dig deep into the causes of low knowledge and poor practices of green chemistry in schools for environmental sustainability.

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