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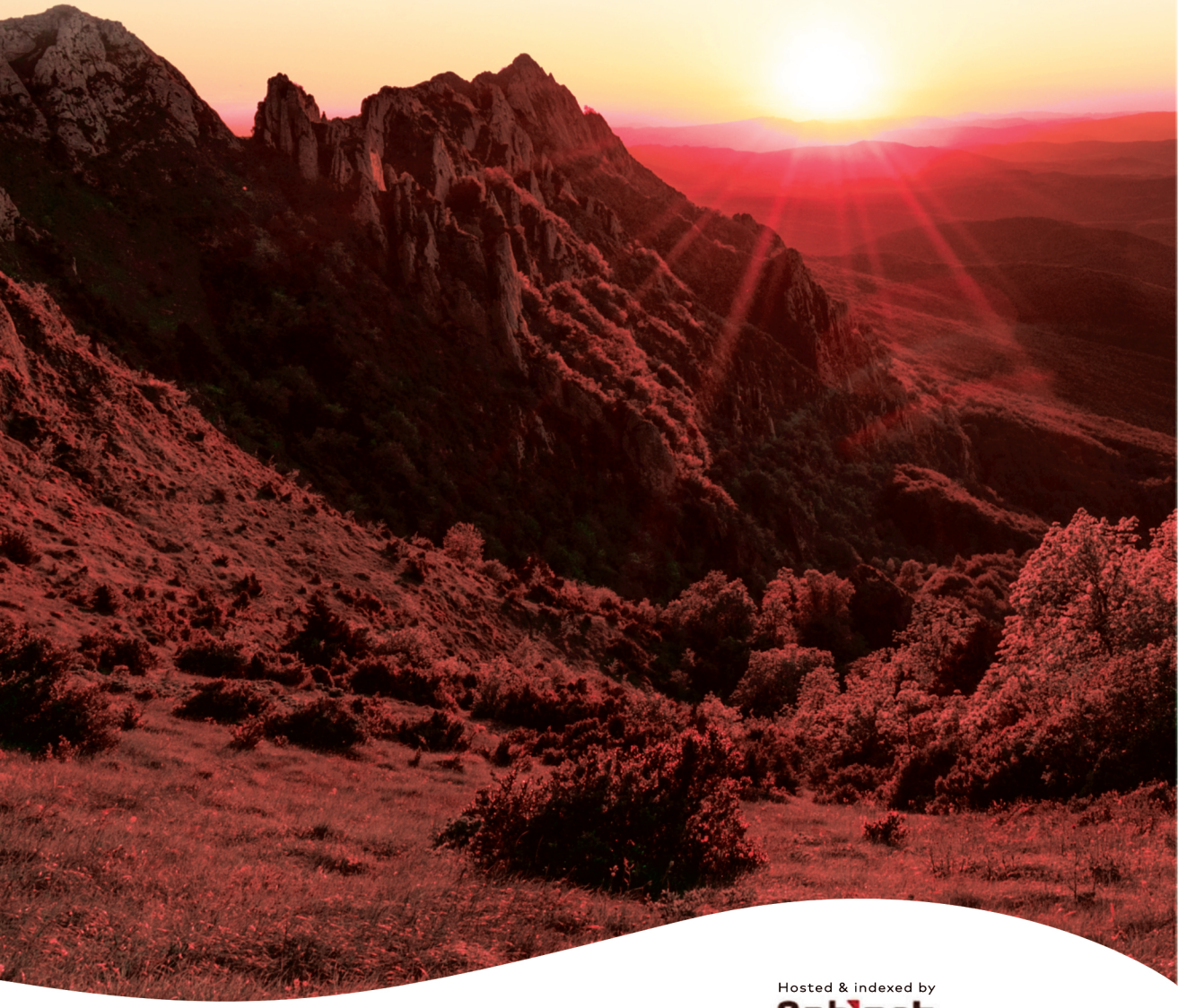

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Awareness of chemistry teachers of gender influence on perceptions and attitudes to green chemistry in Kwara State

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Abstract

Guided by the principles of environmental sustainability, and drawing on extant literature that highlight the limited integration of green chemistry in secondary science education, this study examined the influence of gender on chemistry teachers' perceptions and attitudes towards green chemistry concepts within the secondary school curriculum in Kwara State, Nigeria. The study employed a descriptive survey research design, utilising proportionate sampling to select a sample of 259 chemistry teachers from the three senatorial districts of the state. Data was collected through two instruments, notably, the Teachers' Perception of Green Chemistry Concepts (TPGCC) and the Teachers' Attitudes towards Green Chemistry Concepts (TAGCC). Cronbach's alpha was used to determine the internal consistency of the instruments, with reliability coefficients of 0.97 and 0.99, respectively. Data was analysed using the independent samples t-test. The findings indicated no statistically significant difference between male and female teachers in their perceptions and attitudes towards green chemistry. These results suggest that gender does not constitute a determinant factor in shaping teachers' cognitive or affective dispositions towards environmentally sustainable chemical practices. The study recommended that targeted awareness initiatives and sustained professional development programmes be implemented to enhance teachers' conceptual understanding and instructional application of green chemistry, thereby promoting environmentally responsible pedagogical practices.

Key Words: Gender, Perceptions, Attitude, Green chemistry concept, Curriculum

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Introduction

Science is rooted in an organised body of knowledge developed through a systematic process. This process begins with the careful observation of natural phenomena using human senses, forming the basis for generating hypotheses or designing and conducting experiments. These hypotheses or experiments are then subjected to rigorous testing and validation, ultimately establishing scientific concepts. Unlike other forms of knowledge acquisition, such as a child's understanding that the colours of the Nigerian flag are green and white, science involves the systematic investigation and comprehension of natural phenomena, which embody the principles of scientific inquiry and discovery (Namani & Yusuf, 2025).

In Nigerian secondary schools, science subjects encompass key disciplines such as biology, chemistry, and physics. According to Alebiosu (2017), secondary school students generally exhibit significant interest in science subjects. Chemistry, as a branch of science, comprises two essential aspects: chemistry as a product and chemistry as a process. 'Chemistry' as a product, refers to the acquisition of factual knowledge, core concepts, and established theories, whereas 'chemistry' as a process emphasises the development of scientific inquiry skills, problem-solving abilities, and the attitudes necessary for conducting and applying chemical investigations (Yakubu & Mustapha, 2021).

Solvents play a crucial role in chemical processes. Most solvents used in industrial applications are conventional volatile solvents, which are both hazardous and toxic. Derived from the petrochemical industry, these solvents are expensive and contribute to environmental degradation through the generation of large-scale waste by-products. Despite the existence of safety regulations for their use, prolonged exposure to high concentrations of solvents can result in occupational health issues, including neuropsychological disorders and diminished quality of life (Allam et al., 2018). This shows the need for educational interventions that emphasise the substitution of traditional solvents with safer alternatives, in line with the tenets of green chemistry.

Sustainable development refers to the attainment of human developmental objectives while preserving the ability of natural systems to provide essential resources and ecosystem services (Johnson et al., 2023). Its ultimate goal is to create a society in which human needs are met without jeopardising the integrity of natural systems (Mensah, 2019). Achieving sustainable development requires a holistic approach that integrates economic, social, and environmental

dimensions, fostering a balance between human well-being and environmental preservation. This concept has garnered significant attention across various fields, including education (Hamidah et al., 2017). Beyond renewable energy and sustainable agriculture, sustainable development includes initiatives such as zero waste and green chemistry.

Green chemistry represents a guiding philosophy rather than a distinct sub-discipline of chemistry. It emphasises modern approaches to chemical practices across industries, including the adoption of alternative reaction media and methodologies that adhere to green chemistry principles (Santos & Guidote, 2015; Ivanković et al., 2017). It encompasses 12 fundamental principles which guide the minimisation of hazardous substance usage, maximisation of atom economy, and enhancement of energy efficiency. To incorporate green chemistry into education effectively, a structured and comprehensive teaching approach is necessary. Chemistry teachers play a pivotal role in integrating green chemistry concepts into the senior school chemistry curriculum. This curriculum serves as a standardised framework that outlines tasks designed to enhance students' learning and practical skills. It ensures equitable access to quality education globally, preparing students to contribute meaningfully to society (Federal Republic of Nigeria [FRN], 2013).

The Nigerian chemistry curriculum serves as a strategic framework for addressing societal challenges and advancing national development goals, aligning with the broader objectives of the educational system (Nonyelum, 2018). Secondary education in Nigeria occupies a critical position in the broader education system, serving as a transitional phase between primary and tertiary education. It plays a key role in shaping students' future pursuits and national capacity-building, particularly at higher educational levels (Polycarp et al., 2023; Shamim et al., 2023). The objectives of the secondary school chemistry curriculum are derived from the National Policy on Education, which has undergone several revisions since its inception in 1977 (FRN, 2014). These objectives aim to:

- Foster basic literacy in chemistry for functional living within society.
- Impart fundamental principles and concepts of chemistry.
- Develop essential scientific skills and attitudes for technical applications.
- Encourage creativity.

Teachers are central to the effective implementation of the curriculum. Their perceptions and attitudes towards green chemistry concepts are critical. While

teachers' perceptions shaped by prior knowledge and experiences influence their professional behaviours (Stamatios & Michail, 2020), teachers' attitudes and behavioural intentions significantly impact the success of curriculum reforms. The Theory of Planned Behaviour (Ajzen, 1991) offers a useful framework for understanding how attitudes, subjective norms, and perceived behavioural control jointly shape teachers' intentions to adopt new instructional practices, including green chemistry**.** Recent studies reveal that positive teacher attitudes and a strong sense of self-efficacy are critical predictors of effective curriculum implementation. For instance, chemistry teachers in Kwara State who are aware of gender influences on students' perceptions and attitudes towards green chemistry are more likely to implement the green chemistry curriculum successfully by adapting their teaching strategies to address gender-related learning differences (Abuh & Audu, 2024; Eduwen, Ufuoma & Eze, 2024).

Studies exploring gender influences on teachers' perceptions and attitudes towards green chemistry concepts reveal mixed findings. For instance, Owoyemi and Moju (2020) found no significant gender differences in chemistry teachers' perceptions and attitudes regarding the incorporation of green chemistry into the school curriculum. However, the lack of focus on alternative safer solvents as part of green chemistry concepts is concerning, as their adoption could mitigate hazardous chemical use and foster a safer society. This suggests a pedagogical gap in current instructional practices which warrants targeted inquiry. This study, therefore, investigates the influence of gender on teachers' perceptions and attitudes towards green chemistry concepts in the secondary school curriculum in Kwara State, Nigeria.

This study investigated the influence of chemistry teachers' gender on their perceptions and attitudes towards green chemistry concepts within the secondary school curriculum in Kwara State, Nigeria. Specifically, the study sought to:

- Examine the perceptions of chemistry teachers regarding green chemistry concepts in the secondary school curriculum based on gender.
- Investigate the attitudes of chemistry teachers towards green chemistry concepts in the secondary school curriculum based on gender.

The following null hypotheses were tested at the 0.05 level of significance:

H_{01} There is no significant difference in the perceptions of male and female chemistry teachers towards green chemistry concepts in the secondary school chemistry curriculum.

H_{02}: There is no significant difference in the attitudes of male and female chemistry teachers towards green chemistry concepts in the secondary school curriculum.

Methodology

This study employed a descriptive survey research design, which was adopted to provide a clearer picture of the subject under investigation through quantitative data and detailed explanation. The total population of chemistry teachers in Kwara State was 472. A total of 259 chemistry teachers were sampled using proportionate sampling. The distribution of the sample across the senatorial districts was as follows: 163 chemistry teachers from Kwara Central Senatorial District, 71 from Kwara North Senatorial District, and 96 from Kwara South Senatorial District.

Two instruments were used for the study. The first was the Teachers' Perception of Green Chemistry Concepts (TPGCC), adapted from the work of Jusniar et al. (2023). The second instrument was the Teachers' Attitude towards Green Chemistry Concepts (TAGCC), adopted from the study by Umanah and Udo (2021).

The questionnaires consisted of two sections; Sections A and B. Section A elicited demographic information from respondents, including gender. Section B comprised ten items in two formats that assessed respondents' perceptions of their exposure to green chemistry and their attitudes towards the concept. Both instruments used a four-point Likert scale: Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD), with scores of 4, 3, 2, and 1, respectively.

The instruments were validated by five experts: a secondary school chemistry teacher, a curriculum specialist, a lecturer in tests and measurement, and two lecturers from the Department of Science Education at the University of Ilorin, Nigeria. These experts reviewed the items for relevance, clarity, and appropriateness. Their feedback was incorporated to refine and improve the instruments prior to data collection.

The reliability of the questionnaires was assessed using internal consistency reliability. The instruments were administered to 30 respondents with similar characteristics to those in the main study. The reliability coefficients, calculated using Cronbach's alpha, were 0.97 for the TPGCC and 0.99 for the TAGCC, indicating high internal consistency.

The research hypotheses were tested using inferential statistics (independent samples t-test) at a 0.05 level of significance, as each of the two hypotheses compared groups based on gender (male or female).

Ethical considerations were strictly observed in the conduct of this study. Permission to carry out the research was obtained from the appropriate school authorities and relevant departments. Participants were adequately informed about the purpose and procedures of the study, and their participation was entirely voluntary. Informed consent was obtained verbally and/or in writing, and confidentiality and anonymity were maintained throughout the data collection and reporting processes. The study adhered to the principles of respect for persons, beneficence, and justice.

Results

Table 1: Distribution According to Gender

Variables	Frequency	Percentage
Male	121	47.0%
Female	138	53.0%
Total	**259**	**100.0%**

Table 1 shows that the demographic profile of the respondents provides essential context for interpreting the findings related to secondary school chemistry teachers' perceptions and attitudes toward green chemistry concepts. The gender distribution of the sample was fairly balanced, with a slight majority of female teachers (53.0%) compared to male teachers (47.0%).

Hypothesis Testing

H_{01}: *There is no significant difference in the perceptions of male and female chemistry teachers toward green chemistry concepts.*

Table 2: Independent Samples t-test – Teachers' Perceptions

Gender	N	Mean ($\bar{X}$)	SD	df	t	Sig. (2-tailed)	Remark
Male	121	79.78	6.10	257	-0.31	0.967	Not Rejected
Female	138	79.71	6.27				

Table 2 presents the independent samples t-test comparing male and female teachers' perceptions of green chemistry concepts. The result shows no significant difference between the groups, t=(257) = -0.31, p = .967.

H_{02}: *There is no significant difference in the attitude of male and female chemistry teachers toward green chemistry concepts.*

Table 3: Independent Samples t-test – Teachers' Attitudes

Gender	N	Mean (X)	SD	df	t	Sig. (2-tailed)	Remark
Male	121	58.30	15.62	257	0.35	0.641	Not Rejected
Female	138	58.61	14.91				

As shown in Table 3, there is no significant difference between male and female teachers in their attitudes towards green chemistry concepts, $t(257) = 0.35$, $p = .641$.

Discussion

The findings indicated that there is no significant difference in the perception of male and female chemistry teachers regarding green chemistry concepts in the secondary school chemistry curriculum. This implies a relatively uniform level of awareness and conceptual acceptance across genders, likely influenced by shared exposure to national curricular materials and common preservice teacher training frameworks.

This aligns with Owoyemi and Moju (2020), who also observed no significant gender differences. Likewise, Keleş (2017) found similar non-significant gender effects among Turkish preservice science teachers regarding sustainable education.

Conversely, the findings diverge from Copriady et al. (2021), who observed higher instructional resource proficiency among male teachers, suggesting potential differences in implementation capacity despite similar conceptual attitudes. Such divergence may stem from contextual factors such as availability of resources, institutional support, or prevailing gender norms.

Regarding attitudes, the absence of a significant gender effect indicates that male and female teachers exhibit comparable dispositions towards the integration of green chemistry. This finding suggests a shared level of receptiveness to environmentally sustainable pedagogy. However, Akkor and Gündüz (2018) found that female students demonstrated significantly higher environmental sensitivity. This contrast raises the possibility that gender effects may manifest differently in younger cohorts compared to professional educators.

Conclusion

This study examined the perceptions and attitudes of male and female chemistry teachers toward green chemistry concepts within the secondary school curriculum in Kwara State. The findings revealed no statistically significant differences between the two gender groups.

Recommendations

Based on the findings, the following recommendations are made that:

1. Curriculum development bodies should embed explicit green chemistry modules, highlighting real-world applications and laboratory practices involving safer solvents and reaction pathways.
2. Educational policymakers and curriculum developers should integrate comprehensive green chemistry modules into the senior secondary school curriculum, ensuring alignment with global best practices.
3. Awareness campaigns on the importance of green chemistry should be conducted to sensitise teachers and the wider community about the role of sustainable practices in environmental preservation.
4. Teacher training programmes should be restructured to include hands-on modules on green chemistry principles and experimental safety to bridge the theory–practice gap.

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