Enhancing Students' Academic Achievement in Chemical Reactions Through Computer-Based Molecular Modelling and Hackathon Teaching Strategies

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ABSTRACT

This study was carried out to investigate the effect of computer-based molecular modelling, hackathon teaching strategies and students' academic achievement in Chemistry in secondary schools in Mkpat Enin Local Government Area, Akwa Ibom State, Nigeria. The study adopted a quasi-experimental design with a pre-test and post-test non-equivalent control group design. The population of the study consisted of all the 1840 Senior Secondary School Two (SS2) Chemistry students in the sixteen (16) public co-educational secondary schools in the study area. A sample size of 126 SS2 Chemistry students from 3 intact classes were used for the study. A simple random sampling technique was used in selecting 3 secondary schools out of 16 public co-educational secondary schools in the study area. The instrument for data collection was the Chemistry Achievement Test on the Concept of Chemical Reactions (CATCCR). The instrument was validated by two Chemistry education lecturers and one expert in Measurement and Evaluation. The reliability of the instrument was determined using the Kuder Richardson formula-20 with a coefficient of 0.85. The data generated were analyzed using mean, standard deviation and ANCOVA. The result showed that there is a significant difference in mean achievement scores of Chemistry students taught the concept of chemical reactions using computer-based molecular modelling, hackathon and expository teaching strategies. Students taught using computer-based molecular modelling and hackathon groups performed significantly better than those taught with the expository teaching strategy. There is no significant difference in achievement scores between students taught using computer-based molecular modelling and hackathon strategies. Lastly, there is no significant difference in mean achievement scores of male and female students taught using computer-based molecular modelling, hackathon and expository teaching strategies. It was recommended, among others, that teachers adopt innovative teaching strategies such as computer-based molecular modelling and hackathon teaching strategies for effective teaching and learning of chemical reactions in Chemistry.

Keywords: Students' Academic Achievement, Chemical Reactions, Computer-based Molecular Modelling, Hackathon, Teaching Strategies.

INTRODUCTION

Chemistry is a fundamental science subject taught in senior secondary schools to equip students with the knowledge of chemical concepts and principles essential for scientific and technological advancements. The study of Chemistry serves as the foundation for understanding matter, its properties and the interactions that drive the natural world (Umanah, 2024; Njoku & Attah, 2018). It is the study of matter and describes the behaviour of matter in three different domains: macroscopic (observable phenomena), sub-microscopic (molecular-level interactions), and symbolic (chemical equations and formulas). Effective teaching and learning of Chemistry should incorporate these three domains. These domains provide different perspectives for understanding chemical behavior, yet students often struggle to connect them, especially when instruction emphasizes symbolic representations without sufficient sub-microscopic visualization or real-world applications (Gyasi, Ofoe, & Sumlafo, 2018). This disconnection between the domains impedes students' conceptual understanding and problem-solving abilities, leading to fragmented knowledge, misconceptions, and poor academic achievement in Chemistry.

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One of the Chemistry concepts considered by students as abstract and difficult is chemical reactions, which involve the breaking and forming of chemical bonds to produce new substances (Umanah & Babayemi, 2024; Kotz & Treichel, 2023). Chemical reactions are fundamental to understanding the behavior of matter, providing insights into how substances interact, transform and contribute to various scientific and technological developments (Raven *et al.,* 2014). Chemical reactions are at the heart of literally every biological process in the universe. Life developed on earth as a result of chemical reactions (Helmenstine, 2020). Despite the importance of the concept of chemical reactions, the teaching and learning of chemical reactions remain a serious challenge to both teachers and students. Most Chemistry teachers adopt the traditional, teacher-centred instructional approach often dominated by rote memorization and passive learning with limited emphasis on sub-microscopic visualization (Mihindo, Wachanga, & Anditi, 2017; Umanah & Udo, 2015). This approach fails to provide students with a deep conceptual understanding of reaction mechanisms, molecular interactions and the dynamic nature of chemical processes (Calis, 2018; Rajpoot et al., 2022; Umanah & Babayemi, 2024; Udofia & Sambo, 2021; Umanah & Sunday, 2022). This is evidenced by the consistently low academic performance of students in Chemistry, both in internal assessments and external examinations such as the West African Senior School Certificate Examination (WASSCE).

To address these challenges, recent studies have emphasized the need for innovative teaching strategies that bridge the gap between the macroscopic, sub-microscopic, and symbolic domains (Komssi *et al*., 2015; Jalonen, 2016; Mihindo *et al.*, 2017; Mhlongo & Oyetade, 2017). Such innovative teaching strategies, which allow students to visualize and simulate molecular interactions, enhancing their understanding of complex chemical phenomena, promote critical thinking, creativity, and practical skills are computer-based molecular modelling and hackathon teaching strategies. However, there is no evidence in the literature on the use of these teaching strategies in teaching chemical reactions in secondary schools in Akwa Ibom State, Nigeria. This has, therefore, made it necessary to investigate the enhancing effects of computer-based molecular modelling and hackathon teaching strategies on students' academic achievement on the concept of chemical reactions in Chemistry.

Computer-based molecular modelling teaching strategy is a teaching strategy that uses computers to visualize, simulate and analyze the behavior of molecules and their interactions, helping them gain a deeper understanding of molecular interactions and chemical phenomena. It involves creating virtual models of molecules, predicting their properties, and studying their behavior in different environments. This teaching strategy supports the visualization of chemical phenomena and helps students predict properties or behaviors of molecules based on their structures (Jalonen, 2016; Mihindo, Wachanga & Anditi, 2017). According to Rajpoot *et al.* (2022) and Gyasi *et al.* (2018), the integration of molecular models helps the students to overcome certain learning difficulties in Chemistry. This implies that this visual-based teaching strategy could enhance students’ academic achievement and inculcate a positive attitude towards Chemistry more than the traditional teaching approach, which is deficient in meeting the learners' needs. Jalonen (2016) also reported that computer-based molecular modelling enhanced students' deeper understanding of molecular geometry and bonding concepts, such as isomerism and functional groups. Koomson, Safo-Adu and Antwi (2020) found that that computer simulation and computerized molecular modeling software had a positive effect on the teaching and learning of hybridization.

Hackathon teaching strategy is defined as a teaching strategy where individuals or teams collaboratively work on solving problems or creating innovative solutions, often within a specific timeframe. Participants brainstorm, develop, and present their projects, competing for prizes of recognition. Komssi, Pichlis, Raatikainen, Kindström, and Järvinen (2015) opined that it is an innovative, project-based approach where learners collaborate intensively in a structured, time-limited event to solve real-world problems or create solutions related to a particular subject or theme, thereby promoting critical thinking and practical skills. Hackathon teaching strategy can enhance problem-solving and encourage creativity in students as it engages them in the learning process and retention of new knowledge and development of cognitive abilities (Mhlongo & Oyetade, 2017; Mhlongo, Oyetde & Zuva, 2020). Nandi and Mandernach (2016) reported that peers can be involved in hackathons, where students can teach and learn from their peers and also improve their skills in problem-solving, project management and task priority analysis. Hackathon teaching strategy allows students to learn new technical skills while increasing student interest and engagement in the learning process (Warner

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& Guo, 2017). Gumina (2017) found that participant participation in hackathon events positively impacted their performance. Also, Gama *et al.* (2018) found that there was a positive increase in participant interest and knowledge levels of science, technology, engineering and mathematics when exposed to the hackathon.

Another factor that may influence students' academic achievement in Chemistry is gender. Gender is a psychological term describing the behaviour and attributes expected of individuals based on being either male or female (Umanah 2024; Umanah & Akpan, 2024; Dogo, 2016). While some studies suggest that male students perform better in science subjects, others report no significant gender differences in academic achievement (Dogo, 2016; Sunday & Umanah, 2022; Umanah & Akpan, 2024; Sunday & Edet, 2024). Given these conflicting findings, it is important to explore how gender interacts with teaching strategies such as computer-based molecular modelling and hackathon to influence students' understanding of chemical reactions. This study aims to address these gaps by investigating the effectiveness of computer-based molecular modelling and hackathon teaching strategies in enhancing students' academic achievement in chemistry, with a focus on the concept of chemical reactions. Specifically, the study will evaluate the impact of these strategies in secondary schools in Akwa Ibom State and explore the role of gender in shaping students' performance. By doing so, this research seeks to provide insights into how innovative teaching strategies can improve chemistry education and contribute to better learning outcomes.

Statement of the Problem

The effective understanding of Chemistry requires mastery of chemical concepts and skills across the three fundamental domains: the macroscopic (observable phenomena), sub-microscopic (particle-level explanations), and symbolic (chemical equations and formulas). However, Chemistry instruction often focuses predominantly on the symbolic domain, neglecting the sub-microscopic and macroscopic domains. This disconnection impedes students' conceptual understanding, as they may memorize chemical equations without comprehending the molecular interactions they represent or how these relate to observable phenomena. This lack of coherence leads to fragmented knowledge, misconceptions, and poor academic achievement, as evidenced by consistently low performance in internal assessments and external examinations such as the West African Senior School Certificate Examination (WASSCE). Studies by Gyasi, Ofoe, and Sumlafo (2018) and Mihindo, Wachanga, and Anditi (2017) have highlighted students' struggles in transitioning between these domains, particularly in understanding complex concepts like chemical reactions. To address this issue, the teaching of Chemistry must demonstrate the interconnectedness of the three domains. Research shows that students perform better when they can seamlessly transition between macroscopic, sub-microscopic, and symbolic representations (Njoku & Attah, 2018; Umanah, 2024). However, many teachers lack the skills, tools, or strategies to effectively integrate these domains, often relying on traditional, rote-based methods that prioritize memorization over conceptual understanding. This gap in teaching strategies has contributed to students' poor academic achievement and negative attitudes toward Chemistry. Emerging teaching strategies, such as computer-based molecular modelling and hackathon teaching strategies, offer promising solutions. Computer-based modelling provides visual and interactive simulations that help students understand molecular interactions and symbolic representations of observable phenomena (Jalonen, 2016; Koomson et al., 2020). Similarly, hackathons engage students in collaborative, problem-based activities that integrate all three domains, promoting critical thinking, creativity, and practical skills (Komssi et al., 2015; Mhlongo & Oyetade, 2017). Despite their proven benefits, the adoption of these strategies remains limited, particularly in Mkpat Enin Local Government Area. This study seeks to investigate the effect of computer-based molecular modelling and hackathon teaching strategies on students' academic achievement in Chemistry, with a focus on understanding chemical reactions. By doing so, it aims to provide insights into how innovative teaching methods can bridge the gap between the three domains, improve conceptual understanding, and enhance academic achievement.

Research Questions

The following research questions were formulated to guide the study:

1. What are the mean achievement scores of Chemistry students taught the concept of chemical reactions using computer-based molecular modelling, hackathon and expository teaching strategies?

2. What is the difference in the mean achievement scores of male and female Chemistry students taught the concept of chemical reactions using computer-based molecular modelling, hackathon and expository teaching strategies?

Hypotheses

1. There is no significant difference in the mean achievement scores of Chemistry students taught the concept of chemical reactions using computer-based molecular modelling, hackathon and expository teaching strategies.

2. There is no significant difference in mean achievement scores of male and female Chemistry students taught the concept of chemical reactions using computer-based molecular modelling, hackathon and expository teaching strategies?

RESEARCH METHODS

The study adopted a quasi-experimental design with a pre-test and post-test non-equivalent control group design. This design was chosen because it allows for the comparison of different teaching strategies in real classroom settings without a random assignment of students to groups. The study was conducted in Mkpat Enin Local Government Area, Akwa Ibom State, Nigeria. The study population consisted of 1,840 Senior Secondary School Two (SS2) students from the sixteen public secondary schools in the study area. A sample size of 126 SS2 students (52 male and 74 female) was drawn from three (3) secondary schools. The three schools were selected from the 16 co-educational secondary schools in the area to ensure representativeness using a simple random sampling technique. Intact classes of SS2 Chemistry students in each of the selected schools were used as the sample for the study. In the selected schools, two schools were randomly assigned to experimental groups (Group I: Computer-Based Molecular Modelling Teaching Strategy, CBMM; Group II: Hackathon Teaching Strategy), while the third school was assigned to the control group (Expository Teaching Strategy, ETS). The random assignment of schools to groups was carried out using a lottery method to minimize bias. However, it is important to note that while intact classes were used, no additional measures were taken to control for differences in prior knowledge, teaching styles, or school environments, which could have influenced the results. This is a limitation of the study, as these factors may have introduced confounding variables. The instrument for data collection was the Chemistry Achievement Test on the Concept of Chemical Reactions (CATCCR) developed by the researcher. The CATCCR consisted of two parts: Part A collected personal information such as the name of the school and the gender of the respondents, while Part B consisted of 50 multiple-choice questions with options A-D. The achievement test was administered as a pre-test and post-test to both the experimental and control groups to measure their achievement in Chemistry before and after the interventions. The use of multiple-choice questions was practical for large-scale assessment, but it is acknowledged that this format may not fully capture students' conceptual understanding or problem-solving abilities.

The researcher also developed three lesson packages: one for each experimental group (CBMM and Hackathon) and one for the control group (Expository Teaching Strategy). The lesson packages were aligned with the content of chemical reactions in the SS2 curriculum. For experimental group I (CBMM), computers equipped with MolView and Vlab LabXchange (with PHET simulation) were used for drawing and displaying molecules. Adobe Flash Player version eight or higher (or any other compatible video player) was used to run the computer programs. For experimental group II (Hackathon), students engaged in collaborative, problem-based activities designed to integrate macroscopic observations, sub-microscopic reasoning, and symbolic representations. The control group received traditional expository teaching, which involved direct instruction and rote memorization. To ensure the validity of the CATCCR, the instrument was presented to two Chemistry Lecturers in the Department of Science Education at Akwa Ibom State University and an expert in Measurement and Evaluation in the Department of Psychological Foundations at the University of Uyo for content validation. The reliability of the instrument was determined through a trial test using a sample of 20 SS2 Chemistry students from a school not included in the study sample. The scores obtained from the trial test were analyzed using the Kuder-Richardson (K-20) formula, yielding a reliability coefficient of 0.85, which

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indicates a high level of internal consistency. The research questions were answered using mean and standard deviation, while the hypotheses were tested at a 0.05 probability level of significance using Analysis of Covariance (ANCOVA). The ANCOVA was chosen because it allows for the control of pre-test scores when comparing post-test results across groups. Additionally, the Scheffe Post Hoc test was used to determine exactly which teaching strategies differed significantly from each other.

RESULTS

Research Question One

What is the difference in the mean achievement scores of Chemistry students taught the concept of chemical reactions using computer-based molecular modelling, hackathon and expository teaching strategies?

Table 1: Mean and standard deviation of the difference in the mean achievement scores of Chemistry students taught using computer-based molecular modelling, hackathon and expository teaching strategies (n = 126)

Teaching strategies	n	Pretest		Posttest		Mean Difference
		Mean	**SD**	**Mean**	**SD**	
Computer-based modular modelling	37	28.38	7.96	65.73	12.62	37.35
Hackathon	42	27.86	9.72	62.41	16.71	34.55
Expository	47	28.47	7.74	52.77	14.02	24.30

The results in Table 1 show that the mean pre-test scores of students taught the concept of chemical reactions using computer-based molecular modelling, hackathon and expository teaching strategies were 28.38, 27.86, and 28.47, respectively, with standard deviations of 7.96, 9.72, and 7.74. The mean post-test scores for the three groups were 65.73, 62.41, and 52.77, with standard deviations of 12.62, 16.71, and 14.02, respectively. This indicates that the mean achievement scores of all three groups increased from pre-test to post-test. The mean differences in achievement scores were 37.35 for computer-based molecular modelling, 34.55 for hackathon, and 24.30 for expository teaching. This result showed that computer-based molecular modelling led to the highest improvement in achievement, followed by hackathon and then expository teaching. The higher mean difference for computer-based molecular modelling may be attributed to its ability to provide visual and interactive simulations of molecular interactions, which help students better understand abstract concepts like chemical reactions. Hackathon, while effective, may have been slightly less impactful due to its reliance on collaborative problem-solving, which could vary in effectiveness depending on group dynamics and individual participation.

Research Question Two

What is the difference in the mean achievement scores of male and female Chemistry students taught the concept of chemical reactions using computer-based molecular modelling, hackathon and expository teaching strategies?

Table 2: Mean and standard deviation of the difference in the mean achievement scores of male and female Chemistry students taught using computer-based molecular modelling, hackathon and expository teaching strategies

Teaching strategies	Gender	n	Pretest		Posttest		Mean Difference
			Mean	**SD**	**Mean**	**SD**	
Computer-based Molecular	Male	16	28.50	6.67	67.12	13.76	38.62

Modelling							
	Female	21	28.29	8.97	64.67	11.91	36.38
Hackathon	Male	14	27.57	8.88	63.93	19.39	36.36
	Female	28	28.00	10.27	61.64	15.53	33.64
Expository	Male	22	29.27	7.65	52.00	14.78	22.73
	Female	25	27.76	7.90	53.44	13.60	25.68

The results in Table 2 showed that both male and female students in all three groups experienced an increase in mean achievement scores from pre-test to post-test. However, the mean differences in achievement scores between male and female students were not significantly different across the teaching strategies. For instance, in the computer-based molecular modelling group, the mean difference was 38.62 for males and 36.38 for females. Similarly, in the hackathon group, the mean difference was 36.36 for males and 33.64 for females. While in the expository teaching group, the mean difference was 22.73 for males and 25.68 for females. This indicates that gender did not significantly influence the effectiveness of the teaching strategies. One possible explanation is that both male and female students were equally engaged in the activities, and the collaborative nature of the hackathon and the visual nature of the molecular modelling may have provided an inclusive learning environment.

Hypothesis One

There is no significant difference in the mean achievement scores of Chemistry students taught the concept of chemical reactions using computer-based molecular modelling, hackathon and expository teaching strategies

Table 3: Result of ANCOVA analysis of the difference in the mean achievement scores of Chemistry students taught using computer-based molecular modelling, hackathon and expository teaching strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4021.99[a]	3	1340.66	6.26	.00
Intercept	41283.23	1	41283.23	192.86	.00
Pretest	110.62	1	110.62	.52	.47
Teaching strategies	3891.29	2	1945.64	9.09	.00
Error	26115.22	122	214.06		
Total	480503.00	126			
Corrected Total	30137.21	125			

*Significant at .05 alpha level

The ANCOVA results in Table 3 show an F-value of 9.09 with a probability level of .00 at 2 and 122 degrees of freedom. Since the significance level is less than .05, the null hypothesis is rejected. This indicates that there is a significant difference in the mean achievement scores of Chemistry students taught using computer-based molecular modelling, hackathon, and expository teaching strategies.

Table 4 Summary of Scheffe's post hoc pairwise comparison of students' post-test scores classified by teaching strategies (computer-based molecular modelling, hackathon and expository teaching strategies

(I) Teaching Strategies	(J) Teaching Strategies	Mean Difference (I-J)	Std. Error	Sig.
Computer-based Molecular Modelling	Hackathon	3.33	3.29	.60
	Expository	12.96*	3.21	.00

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Hackathon	Computer-based Molecular Modelling	-3.33	3.29	.60
	Expository	9.64*	3.10	.01
Expository	Computer-based Molecular Modelling	-12.96*	3.21	.00
	Hackathon	-9.64*	3.10	.01

* Significant at p<0.05

The post-hoc analysis in Table 4 shows that there is no significant difference in the mean achievement scores of students taught using computer-based molecular modelling and hackathon teaching strategies (p=.60). However, there is a significant difference between computer-based molecular modelling and expository teaching strategies (p=.00) and between hackathon and expository teaching strategies (p = .01). This indicates that while both innovative strategies are more effective than expository teaching strategy, they are similarly effective when compared to each other.

Hypothesis Two

There is no significant difference in the mean achievement scores of male and female Chemistry students taught the concept of chemical reactions using computer-based molecular modelling, hackathon and expository teaching strategies

Table 5: Result of ANCOVA analysis of the difference in the mean achievement scores of male and female Chemistry students taught using computer-based molecular modelling, hackathon and expository teaching strategies

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4143.68[a]	6	690.61	3.16	.01
Intercept	41107.92	1	41107.92	188.20	.00
Pretest	104.40	1	104.40	.48	.49
Teaching Strategies	4004.26	2	2002.13	9.17	.00
Gender	39.18	1	39.18	.18	.67
Teaching Strategies * Gender	94.60	2	47.30	.22	.82
Error	25993.53	119	218.43		
Total	480503.00	126			
Corrected Total	30137.21	125			

*Significant at .05 alpha level

The ANCOVA results in Table 5 show an F-value of 0.22 with a probability level of .82 at 2 and 119 degrees of freedom. Since the significance level is greater than .05, the null hypothesis is retained. This indicates that there is no significant difference in the mean achievement scores of male and female Chemistry students taught using computer-based molecular modelling, hackathon, and expository teaching strategies.

DISCUSSION OF FINDINGS

The findings of this study showed significant differences in the mean achievement scores of Chemistry students taught the concept of chemical reactions using computer-based molecular modelling, hackathon, and expository teaching strategies. Students taught with computer-based molecular modelling achieved the highest mean scores, followed by those taught with hackathon and, finally, those taught with expository teaching. This finding aligns with previous research, which reports that innovative, interactive teaching strategies enhance students' understanding and academic performance in Chemistry (Mihindo, Wachanga, &

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Anditi, 2017; Jalonen, 2016; Gumina, 2017; Gama et al., 2018). The enhanced achievement of students taught with the computer-based molecular modelling teaching strategy can be attributed to the strategy's ability to provide dynamic 3D representations of molecules and chemical reactions, allowing students to visualize molecular structures and interactions at the submicroscopic level. This helps to bridge the gap between symbolic representations and real-world chemical behaviour, making abstract concepts more concrete. However, it is important to acknowledge the potential limitations of this approach. For example, not all schools may have access to the necessary technology or software required for molecular modelling. Additionally, some students may struggle with the technical aspects of using these tools, which could hinder their learning experience. Future research should explore ways to make molecular modelling more accessible, such as through the use of low-cost or open-source software and teacher training programs to ensure effective implementation. The hackathon teaching strategy also proved effective, though slightly less than computer-based molecular modelling. The result lends credence to the findings of Gumina (2017) who found that students' participation in hackathon positively impact their performance. Also, the result is in line with Gama *et al.* (2018) who found that there was a positive increase in students' interest and knowledge levels of science, technology, engineering and mathematics when exposed to hackathon. This approach leverages collaborative problem-solving and real-world applications to engage students in the learning process, encourages students to think critically and innovatively leading to a deeper understanding of the concepts of chemical reactions. However, the competitive and fast-paced nature of hackathons may not be suitable for all students. Some learners may feel overwhelmed by the pressure to perform within a limited timeframe, while others may struggle with collaboration in group settings. To address these challenges, educators could consider modifying the hackathon format to make it more inclusive, such as by allowing more time for tasks or providing additional support for students who may need it. The study found no significant difference in the mean achievement scores of male and female students across the three teaching strategies. This finding is consistent with previous research, which suggests that gender does not significantly influence learning outcomes in Chemistry when innovative teaching strategies are employed (Sunday & Edet, 2024; Umanah & Akpan, 2024). The inclusive nature of both molecular modelling and hackathons likely contributed to this outcome, as these strategies engage students through visualization and collaboration, which are effective for learners of all genders.

CONCLUSION

Based on the findings of the study, it is concluded that computer-based molecular modelling and hackathon teaching strategies significantly enhanced students' academic achievement in the concept of chemical reactions in Chemistry compared to the expository teaching method. The visual and interactive nature of molecular modelling allows students to engage deeply with complex concepts, while the collaborative and problem-based approach of hackathons fosters critical thinking and innovation. These findings underscore the importance of adopting innovative teaching strategies in Chemistry education to improve student engagement and learning outcomes. Finally, the teaching strategies were gender-friendly, providing equitable learning opportunities for all students.

RECOMMENDATIONS

Based on the findings, the following recommendations were made:

1. Chemistry teachers should adopt computer-based molecular modelling and hackathon teaching strategies to enhance the teaching and learning of chemical reactions.
2. Curriculum planners should incorporate innovative pedagogical strategies, such as molecular modelling and hackathon teaching strategies into the Chemistry curriculum for the teaching of chemical reactions and other abstract concepts in Chemistry. This will ensure that these teaching methods are widely adopted and standardized.
3. The government, in collaboration with professional bodies like the Science Teachers Association of Nigeria (STAN) and the Chemical Society of Nigeria (CSN), should organize seminars and workshops to train teachers on the use of computer-based molecular modelling and hackathon teaching strategies for effective implementation of these strategies.

4. Pre-service teachers should be trained on how to develop and employ computer-based molecular models and hackathons for teaching Chemistry concepts.

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