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Gender as a Predictor of Students' Performance in PhET Simulation of Chemistry Content in Secondary Schools

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ABSTRACT

This research investigated the role of gender in predicting students' performance in Chemistry when using PhET simulations in secondary schools in Kwara State, Nigeria. A quasi-experimental design was utilized, incorporating pre-test, post-test, and control groups. The study involved 80 Senior Secondary School I Chemistry students, selected through purposive sampling. Students' prior performance was categorized using stratified sampling, and PhET simulations were employed to teach Chemistry to the experimental group. The results indicated that gender did not significantly influence performance, as both male and female students showed comparable improvements from pre-test to post-test. Overall, the findings suggest that PhET simulations effectively boost student engagement and performance in Chemistry, regardless of gender.

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1. INTRODUCTION

Student performance is at the heart of the entire educational system. The academic performance of students determines the success or failure of any educational institution (Kumar *et al*., 2021). Schools have very high expectations for their students' academic success because they believe that better academic performance may lead to better employment possibilities and future stability. Performance, as defined by some researchers (Rilwanu *et al*., 2019), is any observable or quantifiable behavior of a human or an animal in a certain setting, usually an experimental one. Consequently, performance measures the acts or a portion of an achievement that are visible at a specific moment (Rilwanu *et al*., 2019). Academic achievement is characterised by the information attained and demonstrated by the grades assigned by the teacher (Anwer, 2019; Fatade *et al*., 2013).

In the context of education, academic performance refers to the learning target that a student, teacher, or institution needs to achieve within a given time frame. Depending on the person or organization, this goal may change. It is evaluated through tests or continuous assessments (York *et al*., 2019). Academic performance is a byproduct of education that quantifies how successfully a student, teacher, or organization has achieved their learning goals (York *et al*., 2019). There was a significant inverse association between academic anxiety and performance (Kumar, 2020). According to some researchers (Badri *et al*., 2006), student performance is important since it appears to be the primary criterion utilized to evaluate the effectiveness and success of any educational establishment. Many factors, such as IQ, personality, environment, and so on, may influence a student's academic success.

One of the contemporary educational concerns of public interest is students' low academic performance, which is a result of their bad performance, especially in public exams and in schools and other higher institutions (Fernandes *et al*., 2019; York *et al*., 2019). Their assertions that students' ongoing underachievement in a range of subject areas is a persistent problem were supported by this (Castejón *et al*., 2016). Some research regarding students' unsatisfactory academic achievement in secondary and postsecondary education was mirrored by this. Students' academic performance is the primary component and one of the primary goals of education. It is defined as their acquisition of knowledge, which is assessed by teachers through grades and/or educational goals that they set for themselves and their teachers to achieve over a predetermined period (Kumar *et al*., 2021; Stone, 2021).

The main objective of academic institutions is to support students in demonstrating enhanced academic performance, which leads to academic excellence (Kumar *et al*., 2021). Furthermore, for anyone concerned about education, academic achievement is a critical component (Jimho, 2019). A lot of significant aspects of the educational system are centred around students' academic achievement, which is why researchers, parents, legislators, and planners are all interested in it, especially when it comes to secondary school education. Since it is often believed that having good marks is a requirement for acquiring good jobs, a better career, and finally a respectable living, academic accomplishment among students is extremely important.

Even though it could seem like a simple outcome of education, students' academic accomplishment has a variety of repercussions on society. Some researchers (Hiliya *et al*., 2023) found that student performance is the primary factor in determining the success or failure of an academic institution. Reaffirmed was the widely held belief that achieving high academic standards opens up more professional options and, thus, leads to a secure future (Kumar *et al*., 2021). Academic success among secondary school students is crucial since it has a direct impact on a country's ability to progress socially and economically. Academic

achievement and the possibility of producing talented workers who can support the nation's social and economic performance are positively correlated, claim some researchers (Kumar et al., 2021).

Students who perform better than expected by society are typically expected to contribute to the advancement, growth, and sustainability of society (Minh & Van Hoi, 2023). According to some researchers (Dodd *et al*., 2021), there is a direct and significant correlation between a country's socioeconomic progress and its students' academic achievement. This is because students' academic performance reveals the relevant information and skill development they have acquired. This provides educators with complete support to make their pupils' academic performance a priority (Kumar *et al*., 2021). Students' educational outcomes are determined by a combination of student-specific inputs (e.g., basic demographics, motivation, interest, learning styles, prior academic attributes, etc.) and environmental attributes (e.g., home and institutional environments, peer relationships, etc.) as well as by the interface between the two (Kim & Kutscher, 2021).

Stated differently, input consists of the qualifications of the teachers, the characteristics of the students, and the available resources (Kumar *et al*., 2021). Curriculum, school administration, and school climate are examples of environment-related characteristics. Output is usually defined by the achievement of the students. A significant amount of research has been conducted to determine the variables that have been linked to the academic success of students. For instance, students entering Higher Education Institutions (HEIs) must negotiate a challenging and complex environment that is unlike anything they have ever encountered. Their poor study habits and inability to meet these expectations may negatively affect their academic achievement (Bilge *et al*., 2014). Some researchers have divided the variables that potentially explain students' academic achievement into two categories (Fryer and Leenknecht, 2023; Kumar *et al*., 2021). These factors include things like clear information, extracurricular training opportunities, social interface, assessment, and feedback, among other instructional features.

The IQ, level of passion, past academic achievement, and learning styles of each student are unique considerations. Many factors that affect students' academic achievement may vary between nations and even between people (Gultom & Oktaviani, 2022). Thus, it would be utterly inadequate to assess students' academic achievement using a single-factor approach (Rodríguez-Hernández *et al*., 2020). In Nigeria, reports of subpar secondary school academic performance date back many years. According to previous studies (Saviour *et al*., 2022), the percentage of candidates who passed the West African School Certificate Examination in 1960 was only 32.36% of all secondary school candidates who registered for the exam. This percentage dropped to 19.3% in 1974 and 27.63% in 1968. These figures show that the main problem with Nigeria's educational system is the terrible performance of students in public exams, particularly secondary school exams.

Based on data submitted at the record office of the Kwara State Ministry of Education in 2018, just 49.24% of all secondary school candidates passed at the five-credit level on the West African School Certificate Examination. It is, therefore, fair to say that both the national education system and secondary schools in Kwara State have a general propensity towards low academic performance. According to Some researchers (Ononye & Obiakor, 2020), who made comments on the phenomenon of widespread failure in the 2009 November/December National Examination Council (NECO) examinations in the Nigerian Tribune on April 5, 2010, the news that 98% of students who took the exam failed could not have come at a worse time for the Nigerian educational system. Tope Ademola works as a public affairs analyst.

According to the report, only 4,223 of the 236,613 applicants who took the exam had credits in five subjects, including maths and English.

Thus, it is pathetic to conclude at this juncture that the nation's incapacity to furnish adequate funding, competent educators for the relevant subjects, infrastructure to accommodate the increase in student body numbers, a fitting curriculum, and other factors, in conjunction with the emergence of politics and society, economic volatility, and the consequences of an inattentive government, have all contributed to a drop in the quality of education. As a result, there has been low academic performance almost everywhere in the country's school system, which has sparked a wave of "sicky" national anxiety. In any type of educational environment, a teacher is an essential resource. According to some researchers (Andriani *et al*., 2018), educators are the most important educational resources. Well-planned structures, well-stocked classrooms, specialised services, and other elements can all contribute to the creation of a good learning environment; nonetheless, competent teachers are still required to deliver the curriculum (Annan, 2020).

The efficiency and effectiveness of the teachers have a direct impact on the academic achievement of the students in any teaching and learning process (Kim *et al*., 2018). Teachers have an ongoing influence on many facets of society. The critical role that educators play in society is demonstrated by the fact that no nation ever excels in the quality of its teachers (Wiggan *et al*., 2021). There is a beneficial association between student achievement and a teacher's quality (Fauth *et al*., 2019). Some researchers (Kayode & Ayodele, 2015) assert that teachers affect pupils at all ability levels but particularly those who have faced significant difficulties. Poor academic performance among Nigerian students may be caused by low-quality teachers and instructional materials (Olufemioladebinu *et al.,* 2018). Some researchers (Cohen & Orrill, 2024) relayed the views of other scholars in a related piece, stating that a quality teacher is the primary factor in a student's academic achievement.

Teachers have a favorable effect on students' learning (Sinaga & Pustika, 2021). Some researchers (Ayeni & Jajua, 2020) believe that the quality of education and student performance in Nigerian secondary schools are determined by the instructor, instructional materials, and subject matter used to teach various topics. Performance refers to the results of exams that students take both before and after learning the relevant material (Laurence, 2022). Students' disinterest and low performance in chemistry are challenges for the subject in our secondary schools (Hassan *et al*., 2015). Some researchers (Nnanna & Chukwunazo, 2021) claim that low student performance in Chemistry can be attributed to several problems, such as inefficient teaching methods, substandard laboratory facilities, and insufficient classroom space relative to the steady rise in student enrolment.

The abstract character of chemistry, student and instructor issues, idea difficulty, and teaching chemistry without instructional resources are among other reasons given for students' low performance in the subject (Nnoli & Nwafor, 2023). Insufficient funding for schools makes it difficult for the administration to give chemistry instructors the necessary teaching resources. Over time, pupils' performance in chemistry has declined nationwide in public examinations administered by the West African Examination Council (WAEC) and the National Examination Council (NECO) (Hassan *et al*., 2015). This is shown in Table 1 regarding the performance of students in WAEC for four consecutive years.

Using the data in **Table 1** as a case study of how students performed on the chemistry exam in Nigerian secondary schools, it is evident that overall student performance has not been exceptional. A significant portion of students failed chemistry, which has a knock-on effect for careers in science. Additionally, chemistry students lack a basic understanding of acids, bases, and acid-base reactions. They are also unable to compute molar and mass concentrations.

These findings highlight the need for improvement in student performance in secondary education.

Fundamental concepts and principles in chemistry are covered in these courses. A review of individuals who passed chemistry at the credit level throughout time indicates that the number of students who enrolled and passed at the credit level has not consistently grown. Dropout rates in science-related disciplines resulted in a significant fraction of registered students failing at the credit level between 2015 and 2018, even though over 50% of them succeeded. As a follow-up, we look into how gender influences students' performance in the PhET simulation of chemistry content in secondary schools in Kwara State.

The main purpose of this study was to investigate the effect of gender as a predictor of students' performance in PhET simulation of Chemistry content in secondary schools in Kwara State. Specifically, the study aims to:

(i) Determine the performance of senior school Chemistry students in a PhET simulation learning environment;
(ii) Examine the difference in performance between pretest and posttest scores of students in PhET simulation Chemistry content;
(iii) find out the significant difference between the male and female pretest performance of Chemistry students in PhET simulation;

Determine the significant influence of gender on the performance of senior school Chemistry students in the PhET simulation learning environment. The following research questions were formulated and answered:

(i) What is the performance of senior school Chemistry students in a PhET simulation learning environment?
(ii) What is the difference in performance between pretest and posttest scores of students in PhET simulation Chemistry content?

The following null hypotheses were formulated and tested at a 0.05 level of significance:

(i) H01: There is no significant difference between the male and female pretest performance of Chemistry students in PhET simulation;
(ii) H02: There is no significant influence of gender on the post-test performance of senior school Chemistry students in the PhET simulation learning environment.

Table 1. Explain Statistics of Students' Academic Performance in WAEC Chemistry (2015 - 2018) (Hassan *et al*., 2015).

Year	Total Sat	Credit Passed (A1-C6)	% Pass	Below Pass (D7-F9)	% Below Pass
2015	680357	412323	60.6	268034	39.4
2016	706873	408122	57.74	298751	42.26
2017	704494	441576	62.68	262918	37.32
2018	728998	451614	61.95	277384	38.05

2. METHODS

The research design that was adopted is a quasi–experimental pre-test, post-test, and control group design. The design adapted a non-randomized sample where we cannot randomly assign subjects, hence, intact classes were used. The population of the study consists of all senior school students in Kwara State, Nigeria, enrolled in Chemistry classes. The target population for this study are senior secondary school One (S.S.S. I) students of

Chemistry in Kwara State. The rationale to select S.S.S. I Chemistry Students is hinged on the selected topics taught using PhET Simulation of Chemistry content and due to the willingness of S.S.S I chemistry students to learn using the PhET simulation because they have been perceiving chemistry as a subject that is too abstract and volatile coming from their JSS. The sample for this was drawn from S.S.S. I Chemistry student in Kwara State. Purposive sampling techniques were adopted to select two intact classes from two separate schools that served as both experimental and control groups accordingly.

Based on the National Policy on Education, a 1:40 is recommended for teacher-student classroom interaction. Therefore, the sample size for this study was 80 S.S.S. I Chemistry Students with 40 Students in each of the groups (Experimental and Control). Then, Stratified Sampling was employed to categorize students' performance in the first term examination result and four strata. This stratum was tailored along the following (**Table 2**).

Table 2. Explain scoring range of Kwara State senior secondary school chemistry students in Four Strata.

Score Range	Remark
1-49	Low
50 – 69	Average
70 – 100	High

Thereafter, Proportional Sampling was adopted to select the 40 participants in each of the schools that constituted both the experimental and control group. The instruments that were used for data collection in this study. The first instrument was the PhET simulation, and the second instrument was the Chemistry Performance Test (CPT), which is the Appendix I. The research instruments were validated by showing the draft copies of the instruments to the seven experts, four lecturers from the department of science education of Al-Hikmah University, Ilorin, Nigeria and three senior secondary schools Chemistry teachers from Government Day Senior secondary school Adeta Ilorin (GL 10), Hikhi-Wanu Nasirdeen senior secondary school Kuntu Ilorin (GL 12) and Ilorin West senior secondary school Osin Aremu Kwara State (GL 12). The experts were required to examine the contents of the instruments to ascertain their suitability for the category of students under investigation.

The observations, suggestions, and comments made by the experts were corrected in the final draft copies of the instruments and which were used for the pilot study outside the locale to determine the reliability of the instrument, and a reliability test was carried out for the instrument using Cronbach Alpha. The reliability test result of 0.79 was obtained. Afterward, we and two other research assistants that have already been trained by us administered the pre-test assessments to both the experimental and control groups to measure their initial understanding of chemistry content, which included Matter, atoms, Molecules, and Chemical equations. Immediately after the administration of the pretest, we introduced the PhET simulations into the chemistry content for the experimental group. The teaching of the control group also took place after the exposure of the experimental group to the PhET simulation of Chemistry contents, and both experimental and control groups lasted for six weeks.

We conducted a post-test assessment on both groups (experimental and control groups) to measure the impact of PhET simulations on learning outcomes. The responses were subjected to both inferential and descriptive statistics. Research questions were answered using mean, frequency count, and standard deviation. All research hypotheses were tested using t-tests.

3. RESULTS AND DISCUSSION

3.1. Initial Data

The demographic data on gender in the study evaluation of PhET simulations of Chemistry content on senior school students' performance in Kwara State reveals an equal number of male and female participants (**Table 3**). Both the pretest and posttest included 40 male and 40 female students, each making up 50% of the group. This even distribution indicates that the study took steps to include both genders equally, ensuring that the results are free from gender bias in evaluating the PhET simulation's effectiveness. Additionally, there was no dropout in the post-test, with all participants completing the study, which adds to the credibility of the findings.

Table 3. Explain Gender of the Participants

Pretest			Posttest		% Absent
Male	**Female**	**Total**	**Male**	**Female**	
40	40	80	40	40	0
50.0%	50.0%%	100%	50.0%	50.0%	0.0%

3.2. Research Question 1: What is the Performance of Senior School Chemistry Students in a PhET Simulation learning Environment?

Table 4 shows the evaluation of senior school students' performance in Chemistry content using PhET simulations reveals generally strong outcomes. The mean score of 30.60, out of a possible 40 marks, reflects a solid average performance across the group. Scores varied from 20 to 38, with most students scoring above 30. While the standard deviation of 5.688 indicates some variability in scores, the majority of students' results were concentrated at the higher end of the scale. Impressively, 60% of the students achieved scores between 33 and 38, indicating that a substantial number of students demonstrated a high level of understanding of the Chemistry content presented through PhET simulations. A small portion of students scored in the lower range (20-26), suggesting that while a few students faced challenges, the overall trend in performance was positive. These findings suggest that PhET simulations were highly effective in supporting students' comprehension and retention of Chemistry concepts, as reflected in the strong performance by the majority of participants.

These findings are consistent with previous research highlighting the effectiveness of PhET simulations in enhancing student performance. Some researchers (Alabi *et al*., 2023) reported that PhET simulations positively influenced students' performance and retention in physics concepts like the kinetic theory of gases and gas laws, with those using simulations showing superior results compared to those who did not. This suggests that simulations can significantly improve students' grasp and retention of complex concepts. Similarly, some researchers (Ouahi *et al*., 2021) found that computer simulations significantly boosted secondary school students' performance in science subjects, supporting the effectiveness of simulations in achieving better learning outcomes.

Some researchers (Ajijolajesu *et al*., 2019) further support these findings, demonstrating that interactive simulations enhance students' achievement and interest in Chemistry without significant gender differences in performance. This aligns with the observed results in Kwara State, where PhET simulations fostered high engagement and understanding among students of both genders. The standard deviation of 5.688 indicates some variability in individual performance, which is consistent with broader studies on educational technology. For example, some researchers (Erdem, 2019) highlighted that the use of technology in

education can produce varied levels of student engagement and motivation, emphasizing the need for customized approaches to meet diverse learning needs.

Table 4. Explain performance of senior school chemistry students in a PhET simulation learning environment.

Scores	Frequency	Percent
20	1	2.5
21	1	2.5
22	1	2.5
23	1	2.5
24	3	7.5
25	6	15.0
26	3	7.5
30	1	2.5
31	1	2.5
33	3	7.5
34	5	12.5
35	4	10.0
36	4	10.0
37	4	10.0
38	2	5.0
Total	**40**	**100.0**
Mean	**30.60**	
Std. Deviation	**5.688**	
Minimum	**20**	
Maximum	**38**	

3.3. Research Question 2: What is the Difference in Performance between Pretest and Posttest Scores of Students in PhET Simulation Chemistry Content?

The data in **Table 5.** illustrates the variation between pretest and posttest scores for students who engaged with PhET simulations in Chemistry. The findings reveal a marked improvement in student performance following the integration of PhET simulations. The pretest mean score for the experimental group was 17.15, with a standard deviation of 4.167, indicating that students initially performed at a moderate level. However, after the PhET simulations were introduced, the mean post-test score increased to 30.60, with a standard deviation of 5.688. This reflects a substantial enhancement in students' understanding and performance as a result of the simulation. Furthermore, the rise in the minimum score from 9 in the pretest to 20 in the posttest further confirms the positive impact of PhET simulations on students' learning outcomes. Likewise, the maximum score advanced from 32 in the pretest to 38 in the posttest, suggesting that even the highest-performing students experienced gains. Overall, these results indicate that PhET simulations greatly improved students' grasp of Chemistry concepts, as evidenced by the significant increase in post-test scores. These results align with prior research advocating for the integration of interactive technology in education to boost student engagement and performance.

Table 5. Explain Difference in performance between pretest and posttest scores of students in PhET simulation chemistry content.

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest Experimental	40	9	32	17.15	4.167
Posttest Experimental	40	20	38	30.60	5.688
Valid N (listwise)	40				

3.4. H01: There is No Significant Difference Between the Male and Female Pretest Performance of Chemistry Students in PhET simulation.

The data provided in **Table 6** evaluates whether there is a significant difference between the pretest performance of male and female Chemistry students who were exposed to PhET simulations. Male students had a mean score of 16.35 with a standard deviation of 4.196, while female students achieved a slightly higher mean score of 17.95 with a standard deviation of 4.084. Despite this minor difference in performance, the t-value of -1.283 and a significance level of 0.215 indicate that this difference is not statistically significant. As the p-value exceeds the 0.05 threshold, the null hypothesis is accepted, meaning there is no significant difference in the pretest performance of male and female students. This suggests that both genders exhibited similar levels of performance before the intervention. Some researchers (Ajijolajesu *et al*., 2019) further support these findings, demonstrating that interactive simulations enhance students' achievement and interest in Chemistry without significant gender differences in performance. This aligns with the observed results in Kwara State, where PhET simulations fostered high engagement and understanding among students of both genders. The standard deviation of 5.688 indicates some variability in individual performance, which is consistent with broader studies on educational technology. For example, some researchers (Erdem, 2019) highlighted that the use of technology in education can produce varied levels of student engagement and motivation, emphasizing the need for customized approaches to meet diverse learning needs.

Table 6. t-test of significant difference between the male and female pretest performance of chemistry students in PhET simulation.

	MEAN	Std. deviation	Std. Error Mean	Df	t	Sig. (2 tailed)	Decision
Male	29.25	6.265	1.401	19	-1.811	0.086	Accept
Female	31.95	4.828	1.080				

3.5. H02: There is No Significant Influence of Gender on the Post-test Performance of Senior School Chemistry Students in the PhET Simulation Learning Environment

The analysis from **Table 7** examines the potential influence of gender on the performance of senior school Chemistry students in a PhET simulation learning environment in Kwara State. The findings reveal that male students had a mean score of 29.25 with a standard deviation of 6.265, while female students achieved a slightly higher mean score of 31.95 with a standard deviation of 4.828. Although there is a noticeable difference in the average performance between the two genders, the t-value of -1.811 and a significance level of 0.086 indicate that this difference is not statistically significant at the standard 0.05 level. Consequently, the results do not provide sufficient evidence to reject the null hypothesis, which suggests that gender does not play a significant role in determining students' performance in the PhET simulation learning environment for Chemistry. Both male and female students

demonstrated similar levels of performance in this setting in Kwara State. Some researchers (Ajijolajesu *et al*., 2019) further support these findings, demonstrating that interactive simulations enhance students' achievement and interest in Chemistry without significant gender differences in performance.

This aligns with the observed results in Kwara State, where PhET simulations fostered high engagement and understanding among students of both genders. The standard deviation of 5.688 indicates some variability in individual performance, which is consistent with broader studies on educational technology. For example, some researchers (Erdem, 2019) highlighted that the use of technology in education can produce varied levels of student engagement and motivation, emphasizing the need for customized approaches to meet diverse learning needs. Additionally, the discussion resonates with empirical studies emphasizing the benefits of simulations in supporting cognitive processes essential for learning complex scientific concepts. For instance, some researchers (Ouahi *et al*., 2021) observed that students in the experimental group using simulations outperformed those in the control group, a pattern that mirrors the results of this study. The improved understanding and skill acquisition facilitated by the PhET simulations suggest that such tools are crucial in addressing the learning challenges often associated with abstract Chemistry concepts.

The analysis also places the findings within the broader context of student performance in Chemistry, particularly concerning historical trends in public examination results in Nigeria. Data from WAEC (2015-2018) highlight ongoing difficulties in achieving high performance in Chemistry, with many students struggling to meet the required standards. The improvement observed in this study underscores the potential of PhET simulations to address these challenges by offering a more interactive and engaging learning experience that enhances understanding of complex Chemistry topics. Moreover, the discussion considers the pivotal role of teachers in effectively utilizing PhET simulations.

Table 7. t-test of significant influence of gender on the performance of senior school Chemistry students in PhET simulation learning environment.

	Mean	Std. deviation	Std. Error Mean	N	df	t	Sig. (2 tailed)
Male	16.35	4.196	0.938	20	19	-1.283	0.215
Female	17.95	4.084	0.913	20			

4. CONCLUSION

The study explored the role of gender as a predictor of students' performance in PhET simulations for Chemistry content in secondary schools across Kwara State. Results indicated that gender had no significant effect on students' performance, as both male and female participants achieved similar outcomes. The equal gender representation among participants reinforced the credibility of the findings by eliminating potential gender bias. Overall, the PhET simulations proved to be highly effective in improving students' grasp of Chemistry concepts. There was a marked increase in post-test scores compared to pre-test results, with the average post-test score significantly higher. Most students performed well, with a large portion scoring in the higher range, underscoring the effectiveness of PhET simulations in promoting engagement and deeper understanding. The analysis of the hypotheses confirmed no statistically significant difference in performance between male and female students in both the pretest and posttest stages. This outcome supports existing research showing that interactive simulations such as PhET can enhance academic performance without creating gender-based disparities. Recommendations are in the following:

(i) Further research should investigate the performance of senior school Chemistry students in a broader range of interactive simulation environments beyond PhET, such as virtual labs and other educational technologies, to compare their effectiveness in promoting students' understanding of Chemistry concepts across various regions.
(ii) Future studies should explore the long-term impact of PhET simulations on students' academic performance by examining the retention of Chemistry knowledge over an extended period.
(iii) Additional research should be conducted to examine the pretest performance of male and female students in other science subjects, using different simulation tools, to determine if gender differences in pretest performance persist across diverse contexts or if this trend is unique to Chemistry.
(iv) Future studies should explore the influence of gender on students' performance in PhET simulations in various educational settings, such as rural versus urban schools or mixed versus single-gender schools, to determine whether contextual factors mediate the relationship between gender and academic outcomes in science simulations.

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