Greener Journal of Educational Research

Vol. 16(1), pp. 81-87, 2026

ISSN: 2276-7789

https://gjournals.org/GJER

DOI: https://doi.org/10.15580/gjer.2026.1.061326084

Effect of Digital Technological Resources on Students' Academic Performance in Chemistry in Senior Secondary Schools in Ebonyi State

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ABSTRACT

This study examined the effect of digital technological resources (DTR) on students' academic performance in chemistry in senior secondary schools in Ikwo LGA, Ebonyi State. Three research questions and three null hypotheses guided the study. A quasi-experimental design using non-randomized pre-test, post-test, control group was adopted. The sample comprised 100 SS2 Chemistry students from two co-educational schools, with 50 students assigned to the experimental group (DTR) and 50 to the control group (lecture method). Data were collected using a 30-item Chemistry Achievement Test (CAT) with a reliability coefficient of 0.87 (KR-20). Mean, standard deviation, and ANCOVA at 0.05 significance level were used for analysis. Findings revealed a significant difference in mean performance scores favoring students taught with DTR over lecture method. Female students significantly outperformed males when taught with DTR. No significant interaction effect existed between gender and teaching strategies. It was recommended that chemistry teachers adopt DTR and curriculum planners integrate DTR as an alternative to lecture method.

ARTICLE'S INFO

Article No.: *061326084*
Type**:** *Research*
Full Text: *PDF, PHP, HTML, EPUB, MP3*
DOI: *10.15580/gjer.2026.1.061326084*

Accepted: *13/06/2026*
Published: *15/06/2026*

Keywords: *Digital technological resources, Academic performance, Chemistry, Gender*

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Article's QR code

INTRODUCTION

Chemistry is a science springing from the principles of physics with its applications in other sciences such as life sciences, engineering, technology, earth sciences and medicine (Suchocki, 2014; Davies, 2008 & Abanikannda, 2016). Okieimen (2007) asserted that chemistry is all about everything in the world. Chemistry is a utility science subject highly valued in important professions such as medicine, pharmacy, engineering, food science, home economics, and agriculture. Chemistry embodies knowledge, attitudes, and skills which are vital for human development and nation building. (Achimugu, 2016). Chemistry is a branch of science that is being taught because of its relevance to the needs of the society. Its teaching helps to instill scientific knowledge and stimulate science oriented attitude in learners. It addresses the needs of majority through its relevance and functionality in content, practice and application. According to Uwague and Ojebah (2008), chemistry is one of the naturally and well established means through which the nation's abundant natural resources can be harnessed into useful ventures for the overall economic and socio-political wellbeing of its citizenry. It has contributed greatly towards life, it forms the bed rock subject for all science and science related courses and that is why it is added it to the lists of courses offered in both secondary and higher institutions due to the fact that Nigeria is a rapidly developing nation with an increasing manpower.

The academic performance of students is the key feature (Ani & Obodo 2023; Rono,et.al., 2014) and one of the important goals of education, which can be defined as the knowledge gained by the student which is assessed by marks by a teacher or educational goals set by students and teachers to be achieved over a specific period of time. (Narad & Abdullah 2016). They also mentioned that the success or failure of any academic institution depends largely upon the academic performance of its students. Academic performance can be understood as the quantifiable and apparent behavior of a student within a definite period and is an aggregate of scores fetched by a scholar in various evaluations through class tests, mid and end of term examinations.(Yusuf,et.al., 2016). It is the extent to which a student's development occurs, both academically and intellectually. A positive attitude towards chemistry leads to a positive commitment to chemistry that influences lifelong academic performance and learning in chemistry. Studies have identified a number of factors influencing Students academic performance in chemistry. Those factors includes active participation in class, ability to learn, ability to utilize instructional materials such as technological resources among many others. With the advent of the Internet and smart devices, access to information is now easier than ever before (Siwawetkul & Koraneekij, 2018). For example, mobile phone technology has a 70% penetration and the majority of worldwide internet traffic is funnelled through smartphones (Boxer, 2018). The ever-present nature of technology in our daily lives facilitates rapid information access and permits alternative approaches to technology enhanced teaching to be adopted during (synchronous) and outside (asynchronous) class contact time (Pricahyo et al., 2018). Technology has been used the classroom since the nineteenth century. Initially devices such as the overhead projector were considered significant advances on more traditional technologies such as the chalkboard the pencil and the ball point pen (Anon, 2018). More recently, rapid advances in computing have revolutionized how technology is implemented to enable learning.

Digital technological resources are powerful tools to support learning. Main contributing factors include their technological characteristics, namely their capacity to record, manage, represent, and communicate data and information. However, the essential contribution of digital technologies to the learning process comes, indirectly, through their pedagogical exploitation. Technologies themselves do not directly cause learning to occur but can afford certain tasks that themselves may result in learning (Udu.et.al., 2021; Dalgarno & Lee,2010). Digital technological resources have been used in education at all educational levels, from primary to higher and adult education and in all disciplines, from science to humanities and social sciences, in various ways. A substantial contribution of digital tools and technologies in teaching and learning processes, especially in science education, is that they create meaningful digital educational environments that in turn contribute to the creation of mental models and provide incentives for learner engagement. (Dalgarno & Lee,2010). Computer technology has become integral to Chemistry Education, not only as a tool for supporting teachers in delivering routine instructional activities but also as a medium for transforming traditional teaching and learning practices into digital formats. Digital technological resources are now employed to address concepts that are abstract, hazardous, or logistically difficult to demonstrate through conventional paper-based or laboratory methods (Dalgarno & Lee, 2010). Dalgarno and Lee further emphasize the pedagogical value of digital technologies in promoting active student engagement through interactive simulations, dynamic visualizations, and analytical tools that enable learners to manipulate variables and observe outcomes in real time. Current research on chemistry teaching supported by digital technologies is essential for identifying emerging trends in instructional theories and for evaluating the effectiveness of new tools being adopted in classroom practice. Despite the importance of digital learning technologies in Chemistry Education, there seems to be a lack of much reviews on the literature regarding digital

tools and technological resources in secondary Chemistry Education. Such reviews outline and organize the existing literature, highlight the technologies used, and the pedagogical approaches followed secondary Chemistry Education. Therefore, they can provide valuable insights into the current state of art in the field to help researchers identify research topics of continuing importance. What is the effect of digital technological resources on students' academic performance in chemistry in senior secondary schools in Ebonyi state and also, is Digital technological resources better than conventional learning approach in enhancing the academic performance of the students in chemistry?

Statement of the problem

The integration of digital technological resources in educational settings has become increasingly prevalent, offering promising opportunities to enhance the learning experience for students. Little attention has been paid to the use of digital technological resources as they affect students' performance in chemistry. The situation has assumed a precarious dimension in secondary schools in Ebonyi state. The failure of educational system to provide adequate and appropriate digital tools and technological resources in order to improve academic performance is of a great concern. As a result of this problem, this research aims to proffer solution by making the findings available to the education bodies. Will the use of digital technological resources by students play significant roles in the performance of students in chemistry in Ebonyi state?

Purpose of the study

The purpose of the study was to investigate the effect of digital technological resources on students' academic performance in chemistry. Specifically, this study determined;

1. The mean performance score of chemistry students taught chemistry using digital technological resources and chemistry students taught chemistry using lecture method
2. The mean performance score of male and female chemistry students taught chemistry using digital technological resources and chemistry students taught chemistry using lecture method.
3. The interaction effect of digital technological resources with gender on students' mean performance scores in chemistry.

Research question

The following research questions were posed to guide this study:

1. What is the mean performance score of chemistry students taught chemistry using digital technological resources and chemistry students taught chemistry using lecture method?
2. What is the mean performance score of male and female chemistry students taught chemistry using digital technological resources and chemistry students taught chemistry using lecture method?
3. What is the interaction effect of digital technological resources with gender on students' mean performance score in chemistry?

Hypotheses

The following null hypotheses were formulated and tested at alpha level of 0.05.

$H0_1$: There is no significant difference between the mean performance score of chemistry students taught chemistry using digital technological resources and students taught using lecture method.

$H0_2$: The mean performance scores of Chemistry students do not differ significantly based on gender when taught using digital technological resources; and students taught using lecture method

$H0_3$: There is no significant interaction effect of digital technological resources with gender on students' mean performance scores in chemistry.

METHODOLOGY

This study adopted a quasi-experimental design, specifically the non-randomized pre-test, post-test, control group design, since random assignment of intact classes was not feasible (Nworgu, 2015). The study was carried out in Ikwo Local Government Area of Ebonyi State, Nigeria. The population comprised all 1,320 Senior Secondary Two (SS2) Chemistry students in Ikwo LGA. A sample of 100 SS2 Chemistry students was purposively drawn from two co-educational schools to ensure gender representation. By lucky dip, one school served as the experimental group and the other as the control group. Two intact classes were used from each school, with the experimental group having 20 males and 50 females (n = 50) and the control group having 20 males and 30 females (n = 50). The instruments were a 30-item Chemistry Achievement Test (CAT) and two researcher-developed lesson plans. The CAT, scored 1 mark per item for a total of 30 marks, was administered as both pre-test and post-test after shuffling item numbers. Face and content validity were established by two specialists from the Department of Science Education, Alex Ekwueme Federal University, using a test blueprint based on Bloom's taxonomy. A trial test on 30 SS2 students outside the study area yielded a reliability coefficient of 0.87 using Kuder-Richardson Formula 20 (KR-20).

The treatment lasted two weeks. The experimental group was taught selected chemistry topics using digital technological resources in the form of video display

animation, while the control group was taught the same topics using the lecture method. Both groups used lesson notes prepared by the researcher to ensure instructional consistency. To control extraneous variables, all lessons were delivered in the students' regular classrooms during normal timetable periods, and ANCOVA was employed with pre-test scores as covariates to adjust for initial group differences. The CAT was administered as a pre-test before treatment and as a post-test one day after treatment. Data were analyzed using mean and standard deviation to answer research questions, while ANCOVA was used to test the null hypotheses at 0.05 level of significance. The two-week interval helped minimize pre-test sensitization and maturation effects.

RESULTS

Answers to Research Questions

Research question 1: What is the mean performance score of chemistry students taught chemistry using digital technological resources (DTR) and that of their counterparts taught the same topic using lecture method?

Table 1: Pre-test, Post-test Mean Performance Scores of Students by Teaching Method (N = 100)

Method	N	Pre-test		Post-test		Gain Score
		Mean	SD	Mean	SD	
Experimental (DTR)	50	8.34	2.28	23.69	3.84	15.35
Control (LM)	50	8.48	2.81	16.96	3.89	8.48
Total/Gain Score Difference	100	8.41	2.55	20.33	4.92	6.87

Summary of result in Table 1 shows that students taught with DTR recorded a higher post-test mean score of 23.69 compared to 16.96 for the lecture method group. The mean gain for the DTR group was 15.35, almost double the 8.48 gain of the control group. This suggests DTR was more effective in improving students' understanding of chemistry concepts than the traditional lecture method.

Research question 2: What is the mean performance score of male and female chemistry students taught chemistry using digital technological resources?

Table 2: Pre-test, Post-test Mean Performance Scores of Male and Female Students in DTR Group (N = 50)

Gender	N	Pre-test		Post-test		Gain Score
		Mean	SD	Mean	SD	
Male	20	9.55	2.56	22.90	4.10	13.35
Female	30	7.83	1.96	24.02	3.72	16.19
Total/Gain Score Difference	50	8.34	2.28	23.69	3.84	-2.84

Table 2 revealed that female students in the DTR group had a higher post-test mean of 24.02 than males who had 22.90, despite males starting with a higher pre-test mean. The mean gain for females was 16.19 compared to 13.35 for males. This indicates that DTR enhanced learning outcomes for female students more than for male students in this sample.

Research question 3: What is the interaction effect of teaching strategies with gender on students' mean performance score in chemistry?

Table 3: Estimated Post-test Means by Method and Gender (N = 100)

Dependent Variable: Post-test score (Estimates)

Group	Gender	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Experimental	Male	19.074[a]	.605	17.876	20.272
	Female	20.839[a]	.386	20.073	21.604
Control	Male	9.440[a]	.388	8.671	10.209
	Female	8.146[a]	.246	7.658	8.634

Covariates appearing in the model are evaluated at the following values:
Pre-test = 8.41 & post-test = 20.33

Summary of result presented in Table 3 revealed that across both genders, students taught with DTR scored higher than those taught with lecture method. Although females outperformed males in the DTR group, both male and female students in the DTR group had substantially higher adjusted means than their counterparts in the lecture group. This pattern shows that DTR improved performance regardless of gender, indicating no significant interaction effect.

Testing Hypotheses

The three hypotheses were tested using ANCOVA. Summary of the analysis for the three null hypotheses is shown in Table 4.

Hypothesis 1: There is no significant difference between the mean performance score of chemistry students taught chemistry using digital technological resources (DTR) and their counterparts taught the same topic using lecture method.

Table 4: ANCOVA Summary for Students' Performance by Method and Gender (N = 100)

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	1674.82[a]	4	418.70	34.20	.000	
Intercept	1762.99	1	1762.99	144.01	.000	
Pretest	320.85	1	320.85	26.21	.000	
DTR	1062.26	1	1062.26	86.77	.000	S
Gender	73.04	1	73.04	5.97	.016	S
Method * Gender	6.39	1	6.39	0.52	.472	NS
Error	1163.08	95	12.24			
Total	49297.00	100				
Corrected Total	3070.44	99				

S = Significant; NS = Not Significant at p < .05

The ANCOVA result for teaching method in Table 4 shows an F-value of 86.77 with a significance value of .000, which is less than the alpha level of 0.05. Therefore, the null hypothesis stating that there is no significant difference between the mean performance score of chemistry students taught using digital technological resources and those taught using lecture method is rejected. This indicates that the type of instructional strategy had a statistically significant effect on students' academic performance in chemistry. The result confirms that students exposed to DTR achieved significantly higher post-test scores than their counterparts taught with the lecture method, after controlling for pre-test differences.

Hypothesis 2: The mean performance scores of Chemistry students do not differ significantly based on gender when taught using digital technological resources; and students taught using lecture method

The ANCOVA result in Table 4 shows that the analysis yielded an F-value of 5.97 with a significance value of .016, which is also below the 0.05 threshold. Hence, the null hypothesis that the mean performance scores of male and female chemistry students do not differ significantly is rejected. This implies that gender had a significant main effect on academic performance when DTR was used. Based on the descriptive data, female students recorded higher adjusted mean scores than male students, suggesting that DTR enhanced the academic performance of female students more than males in chemistry.

Hypothesis 3: There is no significant interaction effect of digital technological resources with gender on students' mean performance scores in chemistry.

The ANCOVA result in Table 4 shows that the interaction effect between teaching method and gender produced an F-value of 0.52 with a significance value of .472, which exceeds the 0.05 level of significance. Consequently, the null hypothesis of no significant interaction effect of digital technological resources with gender on students' mean performance scores is not rejected. This means that although both method and gender independently influenced performance, the effectiveness of DTR was not dependent on the students' gender. In other words, DTR improved chemistry achievement for both male and female students, and the magnitude of improvement was consistent across gender.

DISCUSSION OF THE FINDINGS

Students taught chemistry using digital technological resources achieved higher mean scores, than those taught using the lecture method, and the difference in their mean performance scores were statistically significant. Digital Technological Resources (DTR) was

superior to the lecture method in facilitating the performance of the learners. The finding of this study is in line with the observations of Ogunbodede & Oribhabor (2022) they found out students that learned using Digital Resources had high performance scores than students who learned through the lecture method of teaching. The study also agreed with observations of Kumi et al. (2020) they found out that students taught with Digital Technologies performed better in the learning environment. The finding of this study is in line with the constructivists' theory which revealed that the students can construct their own knowledge by interacting with the objects in their environments. Constructivists admit that effective learning occurs when the learner is actively involved during teaching and learning encounter and therefore advocate for hands-on and minds-on pedagogy which Digital Technological Resources provides. The differences in performance scores of students might have been as a result of the type of instructions presented to them. In DTR lesson, all learners had equal chances of learning and constructing their knowledge. The use of the digital technological resource in the teaching made the facilitator and students to interact very well which made the students to freely express their opinions and it created opportunities for a deeper sense of responsibility for student during the learning process which made the students to learn concepts more than contents.

There was a significant difference between the mean performance scores of male and female students taught organic chemistry using DTR in favor of the female students. The findings of this study revealed that female students had slightly higher mean performance score than their male counterparts. This implies that DTR enhanced the academic performance of female students' more than the male students in chemistry. The findings from this study agreed with the findings of Aniodoh (2012) where girls out-perform boys in Chemistry, though the finding of this result disagreed with Adam & Hassan (2017) they found out that there is no significant difference between male and female students' academic performance in Mathematics.

There was no significant interaction between gender and teaching strategies on the performance scores of the students because both male and female students in the treatment (DTR) group clearly had higher mean performance scores than those in the control group. The finding of this study showed that there was no significant interaction effect of method and gender on students' mean performance scores in chemistry. This was evident in that DTR is superior to lecture method at the two levels of gender (male and female). However, the performance of the female students was higher than that of their male counterpart in both the mean performance scores.

CONCLUSION

The study established that digital technological resources significantly improved students' academic performance in chemistry compared to the lecture method in Ikwo LGA, Ebonyi State. DTR promoted active engagement, visualization of abstract concepts, and deeper interaction, which align with constructivist learning principles. While both male and female students benefited from DTR, female students recorded significantly higher performance gains. Importantly, the effectiveness of DTR was not dependent on gender, as no significant interaction effect was found. Therefore, DTR is a gender-neutral instructional strategy that can enhance chemistry achievement in secondary schools.

Recommendations

In line with the findings of this study, the researcher made the following recommendations;

1. Chemistry teachers should integrate digital technological resources such as animations, simulations, and interactive videos into classroom instruction to improve students' performance.
2. The Ministry of Education and curriculum planners should revise the chemistry curriculum to formally include DTR as a recommended instructional strategy alongside traditional methods.
3. Schools should provide regular training, workshops, and seminars for teachers to build competence in selecting and using appropriate DTR for different chemistry topics.
4. Government and school administrators should invest in ICT infrastructure, electricity, and internet access to ensure DTR can be effectively deployed in public secondary schools.
5. Teachers should adopt gender-responsive approaches when using DTR to further close performance gaps and sustain the interest of both male and female students in chemistry.

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Cite this Article: Mbamalu, OJ; Ufopu, CV (2026). Effect of Digital Technological Resources on Students' Academic Performance in Chemistry in Senior Secondary Schools in Ebonyi State. *Greener Journal of Educational Research*, 16(1): 81-87, **https://doi.org/10.15580/gjer.2026.1.061326084.**