Effectiveness of Synchronous and Asynchronous e-learning on SS2 interest and academic achievement on electrolysis in Calabar Municipality, Nigeria

[1]**Ndomah Juliana Ikot**
julietndoma@gmail.com

Cecilia Obi Nja, Ph.D
Department of Physical Science Education
University of Calabar, Calabar
conja@unical.edu.ng

[1]**Essien Queency Etim, Ph.D**
Queencychem@gmail.com
[1]*Cross River State College of Nursing Science, Calabar*

Abstract

The study investigated the effectiveness of synchronous and asynchronous e-learning on SS2 interest and academic achievement on electrolysis in Calabar Municipality, Nigeria. The quasi-experimental design was adopted. Two research questions and two hypotheses were formulated to guide the study. The population included 1,661 SS II Chemistry students. A sample of 120 SS2 students, drawn from four intact classes in four schools, was used. The instruments used for data collection were Chemistry Achievement Test (CAT) and Chemistry Interest Scale (CIS). The reliability of the research instruments was established using Kuder Richardson formular (K-R-20) for CAT and Cronbach alpha for CIS with reliability coefficients of .727 and .755 respectively. The research questions were answered using mean and standard deviation while the Analysis of Covariance (ANCOVA) was employed to test the hypotheses. The result of the analysis showed, among others that there is a significant difference between the mean scores of SS2 chemistry students' interest when taught with synchronous and asynchronous e-learning. The researchers recommend that synchronous e-learning should be integrated into the curriculum of secondary school students studying chemistry.

Keywords: e-learning, synchronous learning, asynchronous learning, interest, academic achievement

Ndomah Juliana Ikot, Cecilia Obi Nja, Ph.D & Essien Queency Etim, Ph.D

Introduction

Chemistry is a branch of science that deals with the study of matter, its composition, structure, properties and the changes it undergoes when used or utilized. Chemistry is often referred to as the "central science" including physics, geology and biology, mathematics, due to its role in explaining fundamental aspects of matter and its transformations (Atkins & De Paula, 2014). The principle of chemistry involves molecular interaction and reaction, making it crucial for advancement in fields like medicine, environmental science and engineering (Oginni et al., 2013). The impact of chemistry extends far beyond the laboratory. It plays a pivotal role in addressing global challenges such as energy production, environmental protection, and public health. For instance, chemists develop sustainable energy solutions like solar cells and batteries, create new materials with specific properties for technology and industry, and innovates pharmaceuticals and medical treatments to improve health outcomes (Nja & Okri, 2024).

However, all these benefits depend on the learning outcome of the students in Chemistry. Chemistry as a subject of study is mandatory for students who aspire to study science-based courses in Nigerian tertiary institutions. Therefore, to qualify for admission into these higher institutions of learning, one must pass chemistry with at least a credit, in addition to other subject requirements (Nyong, 2024).

Despite the importance of Chemistry in the development of Nigerian economic, technological, medical and educational systems, students' academic achievement in Chemistry has been reported to be poor. A study by Nja (2012) revealed that students' achievement in Chemistry has consistently been poor. Students' academic achievement in chemistry as a science subject at the secondary education level is low over a period of years. In 2022, the percentage of failure rate was 63.64%, and in 2023, the percentage of failure rate was 61.80%. The review of students' achievement in Chemistry within five-year period (2019-2023) shows that only small percentage of the entire students who registered were able to pass Chemistry at a credit level and above.

Poor achievement in science subjects has been attributed to various factors, with teaching approaches being a critical component. Traditional methods, such as lecture-based instruction, have dominated science teaching for years, focusing on rote memorization rather than fostering critical thinking and problem-solving skills. This approach often leaves students disengaged and unable to apply scientific concepts to real-life situations. Research indicates that when students are passive recipients of information, they struggle to retain and apply knowledge effectively, resulting in poor academic performance in science subjects

(Oladejo & Owoeye, 2021). Modern educational theories emphasize the importance of active learning, where students are more involved in their learning process; but this shift has been slow in many classrooms.

The limited use of technological device in science education also contributes to poor students' outcomes. Interactive technologies such as synchronous and asynchronous e-learning tools have been shown to enhance students' understanding of abstract scientific concepts (Nja et al., 2025). However, due to either lack of access or insufficient training, many teachers rely on traditional methods without incorporating technology. A study by Yadav and Mishra (2021) found that students exposed to interactive, technology-enhanced learning environments performed significantly better in science subjects than those taught using conventional methods.

E-learning is an online learning platform that emerges in a formal context and utilizes a variety of multimedia technologies. Electronic hardware and software support this system either offline or online. A personal computer is usually used for delivering training or computer-enhanced learning related to e-learning. It is based on technology for improving classroom engagement through positive environment, where students are deliberately engaged in online tutorials for completing a task assigned to them. E-learning ensures that students are completely involved as learning takes place together with texts, videos, sounds, collaborative sharing, and interactive graphics. It may enhance the quality of teaching and learning (Al-Rawashdeh et al., 2021). E-learning, defined as the use of electronic media and information and communication technologies (ICT) in education, encompasses a wide range of activities from online courses and digital learning resources to interactive and collaborative tool (Garrison & Vaughan, 2018). The growth of e-learning has been facilitated by the widespread adoption of computers and internet technology, and was further accelerated by the COVID-19 pandemic, which led to a surge in demand for online learning solution.

Synchronous e-learning involves real-time interaction between instructors and students through digital platforms. Tools such as video conferencing, live chats, and webinars facilitate immediate feedback and engagement, which can enhance understanding and retention of complex scientific concepts (Hrastinski, 2008). This type of e-learning mirrors traditional classroom dynamics, promoting active participation and fostering a sense of community among students (Chiu et al., 2020). For science education, synchronous e-learning can simulate laboratory discussions and collaborative problem-solving sessions, which are crucial for mastering scientific methods and principles (Nguyen & Tran, 2021).

Asynchronous e-learning allows students to access learning materials and complete assignments at their own pace. This flexibility supports diverse learning schedules and styles, enabling students to review and reflect on content as needed (Means, 2016). Asynchronous tools include recorded lectures, discussion forums, and digital libraries. In science education, Asynchronous e-learning can provide extensive resources for self-study, allowing students to delve deeper into topics and conduct independent research, which is essential for developing critical thinking and analytical skills (Garrison & Kanuka, 2019).

Beyond e-learning type, interest is a very strong determinant in the teaching and learning of Chemistry. Interest refers to a student's curiosity, motivation or enthusiasm for learning about a particular subject or activity (Renninger & Hidi, 2016). The rate of achievement in chemistry is determined by the level of interest developed by the student. Interest in a subject is a critical determinant of academic success, as it drives motivation and engagement. Research suggests that students who are more interested in a subject are likely to achieve higher academic outcomes (Renninger & Hidi, 2016). It is based on this that the researchers explored the comparative effectiveness of synchronous and asynchronous e-learning type on Chemistry students' interest and academic achievement in Calabar Municipality.

Nja et al. (2024) researched on synchronous learning and its impact on Biology students. The study made used of ANOVA in testing the hypotheses. The result of the study showed that synchronous learning improved students' interest by 30% compared to asynchronous learning. Chen and Zhang (2020) researched the effects of synchronous e-learning on students' academic achievement and engagement. The findings revealed that synchronous e-learning significantly enhanced students' engagement, particularly through real-time interactions and immediate feedback, which led to improved academic performance. The study concluded that integrating synchronous elements into online learning environments fosters a more dynamic and participatory experience for students, thus positively impacting their academic outcomes.

In a study by Johnson and Peters (2021), they examined the impact of asynchronous learning on students' motivation and interest, focusing on 500 high school students in the United States. The results indicated that asynchronous learning, characterized by self-paced modules and flexible timelines, fostered higher levels of intrinsic motivation among students. This approach enabled learners to better manage their schedules and engage deeply with course material at their own pace. However, the lack of real-time interaction led to lower external motivation, as students reported feeling less connected to peers and instructors. Despite this, academic achievement remained strong, with the flexibility provided by asynchronous

learning supporting better retention and mastery of content. Johnson and Peters concluded that while asynchronous learning enhances self-directed learning and content comprehension, it requires additional support mechanisms, such as discussion forums, to address potential isolation.

A study by Chen and Zhang (2020), titled "the impact of synchronous e-learning on academic achievement and students' engagement" in China, focused on how real-time virtual learning environments affect students' outcomes. The analysis was done using ANOVA to test the hypotheses. Results revealed that synchronous e-learning significantly enhanced both academic achievement and students' engagement, as the live interaction between students and instructors fostered immediate feedback, active participation, and collaborative learning. However, some students experienced challenges due to technology issues or the intensity of live sessions.

Johnson and Peters (2021), conducted a study titled "asynchronous learning and its effects on student motivation and achievement" in Biology in the USA, investigating the impact of flexible, self-paced online learning on students' performance and motivation. The study sampled 400 undergraduate students across multiple universities and utilized survey, academic performance data, and motivation scales as the primary tools. Findings showed that asynchronous learning positively affected academic achievement, particularly for self-motivated and independent learners, as it allowed students to manage their time effectively and revisit materials at their own pace. However, the lack of real-time interaction and immediate feedback led to lower engagement for students who preferred structured guidance and peer collaboration.

Ali and Khan (2019), conducted a study titled "synchronous learning in online classrooms: impacts on STEM students' achievement" in Egypt, exploring the effect of real-time online instruction on the academic performance of STEM students. Results indicated that synchronous learning had a significant positive impact on students' achievement in STEM subjects, particularly in enhancing understanding of complex concepts through interactive problem-solving and immediate feedback from instructors. Students also reported greater engagement and collaboration with peers during live sessions, which contributed to improved academic outcomes.

Martin and Garcia (2021) examined the role of synchronous e-learning in enhancing students' collaboration and academic success in physics among 300 university students in Madrid, Spain. The findings revealed that synchronous e-learning significantly improved students' collaboration, as live discussions, group work, and instant feedback facilitated more

interactive and cooperative learning experiences. This collaborative ment not only fostered a sense of community but also contributed to better academic performance, particularly in group-based projects and assessments. Students reported feeling more connected to their peers and instructors, which boosted their motivation and overall learning experience.

Statement of the problem

The benefit of student's interest and academic achievement in chemistry is critically important as it serves as a foundation for future educational and career opportunities. When students are genuinely interested in a subject, they are more likely to actively engage in learning activities, ask questions and seek a deeper understanding of concepts. This intrinsic motivation not only enhance their overall learning experience but also fosters a positive attitude toward academic challenges.

Despite the numerous importance of chemistry, the researchers observed that there is persistence in poor interest and academic achievement in chemistry, considering the analysis of result, conducted by WASSCE from (2019-2023) and other issue associated with students' characteristics, instructional and classroom interaction, teacher teaching method and school location. This lack of interest may have led to poor achievement in chemistry and the general poor performance at external examination such as NECO and WAEC. A number of strategies have been adopted by Chemistry educators and experts in the field of education to find solutions to this problem of poor achievement in Chemistry, but to no avail. The question that this present study seeks to provide an answer is, what is the effect of synchronous and asynchronous e-learning on SS2 students' interest and academic achievement in Chemistry in Calabar Municipality, Nigeria?

Purpose of the study

The study aimed at a comparative study of the effectiveness of synchronous and asynchronous e-learning on SS2 Chemistry students' interest and academic achievement in Calabar Municipality, Nigeria. Specifically, the study seeks to determine:

1. The difference between the mean interest response score of chemistry students taught with synchronous and those taught with asynchronous e-learning method.

2. The difference between the mean academic achievement response score of chemistry students taught with synchronous and those taught with asynchronous e-learning method

Research questions

The following research questions were formulated to guide the study:

1. What is the difference between the mean interest response score of chemistry students taught with synchronous and those taught with asynchronous e-learning method?

2. What is the difference between the mean academic achievement response score of chemistry students taught with synchronous and those taught with asynchronous e-learning method?

Hypotheses

The following null hypotheses were formulated to guide the study:

Ho1: There is no significant difference between the mean interest response score of chemistry students taught with synchronous and those taught with asynchronous e-learning method.

Ho2: There is no significant difference between the mean academic achievement response score of chemistry students taught with synchronous and those taught with asynchronous e-learning method.

Methodology

A quasi-experimental research design was adopted for the study. Specifically, non-randomized pre-test, post-test research design was chosen, because it allows the assessment of the effect of each treatment group in the intact classes. The design is a modification of pre-test post-test with two experimental groups and two treatment variables. The population of this study comprised all SS2 students offering chemistry in both public and private schools in Calabar Municipality Local Government Area of Cross River State, Nigeria. The total population of SS2 chemistry students in the LGA was 1,661. The study used simple random sampling technique. The sample comprised one hundred and twenty (120) senior secondary school students offering chemistry from four (4) schools in the Calabar Municipality Local Government Area.

The two instruments used for data collection were Chemistry Interest Scale (CIS) and Chemistry Achievement Test (CAT). Chemistry interest scale (CIS) contained 10 items while CAT consisted of 50 multiple choice objective questions with four response options, A – D. The reliability coefficients of the research instruments were established using Kuder Richardson formular (KR-20) for CAT and Cronbach alpha for CIS, with reliability coefficients of .727 and .755 respectively. The data collected from pre-test, and post-test of the study for interest and academic achievement were analysed using descriptive statistics of mean and standard deviation and analysis of covariance (ANCOVA) at 0.05 level of significance.

The study was carried out during second term of 2024/2025 academic year. The procedure involved the administration of pre-test (chemistry interest scale and chemistry academic achievement) to both synchronous and asynchronous group before teaching for 2 hours. Teaching in both groups lasted for 4 weeks. At the end of the teaching period, a post-test was given to test for interest and academic achievement of students in the two groups.

Presentation of results

Ho1: There is no significant difference between the mean interest response score of chemistry students taught with synchronous and those taught with asynchronous e-learning method.

Table 1: Summary of the ANCOVA of students' interest in chemistry when taught with synchronous and asynchronous e-learning

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	35.851[a]	2	17.925	3.955	.022	.063
Intercept	2485.855	1	2485.855	548.480	.000	.824
Pre-interest	.059	1	.059	.013	.909	.000
Treatment	35.468	1	35.468	7.826	.006	.063
Error	530.274	117	4.532			
Total	150733.000	120				
Corrected Total	566.125	119				

*$p < .05$

The results in table 1 indicate that the calculated F value is 7.826 and is statistically significant at .05 significance level at (1, 117) degrees of freedom. The calculated p-value of .006 (p< .05) was lower than .05 level of significance needed to take decision. That means there is a significant difference in the mean interest scores of students when taught chemistry concepts with synchronous and asynchronous e-learning approaches. Therefore, the null hypothesis is rejected.

Ho2: There is no significant difference between the mean academic achievement response score of chemistry students taught with synchronous and those taught with asynchronous e-learning method.

Table 2: Summary of the ANCOVA of students' academic achievement in chemistry when taught with synchronous and a synchronous e-learning

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2832.568[a]	2	1416.284	41.376	.000	.414
Intercept	22541.078	1	22541.078	658.520	.000	.849
Pre-test	48.009	1	48.009	1.403	.239	.012
Treatment	2832.233	1	2832.233	82.741	.000	.414
Error	4004.899	117	34.230			
Total	229406.000	120				
Corrected Total	6837.467	119				

*p< .05

The results in Table 2 indicate that the calculated F value is 82.741 and is statistically significant at .05 level of significance at 1, 117 degrees of freedom. That means there is a significant difference in the mean academic achievement of students taught with synchronous and asynchronous e-learning. Therefore, the null hypothesis is rejected.

Discussion of the findings
The first hypothesis sought to find out chemistry students' interest when taught with synchronous e-learning and asynchronous e-learning. The results indicated that there is a significant difference between the mean score of SS2 chemistry students' interest when taught with synchronous and asynchronous e-learning types. Synchronous e-learning type had a higher mean score than asynchronous e-learning type. This result may be so as synchronous online learning occurs in real-time, where instructors and students interact simultaneously through digital platforms. This type of e-learning includes live lectures, webinars, and video conferencing, enabling immediate feedback, active participation, and real-time discussions. One key advantage of synchronous e-learning is the ability to create an interactive and engaging learning environment similar to traditional classrooms, fostering collaboration among students and instructors. This active students' engagement would have been responsible for their increase in interest in chemistry.

This study corroborated earlier study by Nja et al. (2024) who researched on synchronous learning and its impact on Biology students' engagement. The result of the study showed that synchronous learning improved students' interest by 30% compared to asynchronous learning. Chen and Zhang (2020) researched the effects of synchronous e-learning on students' academic achievement and engagement. The findings revealed that synchronous e-learning significantly enhanced students' engagement, particularly through real-time interactions and immediate feedback, which led to improved academic performance. The study concluded that integrating synchronous elements into online learning environments fosters a more dynamic and participatory experience for students, thus positively impacting their interest. It was recommended that educational institutions should invest in synchronous technologies to boost both engagement and academic success and interest.

Results from the second hypothesis indicated that there is a significant difference in the mean academic achievement of students taught with synchronous and asynchronous e-learning. The significant difference recorded in the analysis which was attributed to the synchronous e-learning type may have been because synchronous e-learning has capacity for real-time interaction. Learners can ask questions, receive immediate feedback, and participate in discussions during live sessions. This format encourages active participation and engagement, which can enhance learning outcomes.

This study corroborated earlier study by Martin and Garcia (2021), which examined the role of synchronous e-learning in enhancing students' collaboration and academic success among 300 university students in Madrid, Spain. The results revealed that synchronous e-learning significantly improved students' collaboration which contributed to better academic performance. This study also agrees with the study by Nguyen and Tran (2021), that explored the impact of synchronous learning on STEM education in Hanoi, Vietnam, focusing on 300 high school students. The findings revealed that synchronous learning significantly boosted students' understanding of complex STEM concepts, especially in mathematics and physics, due to the real-time interaction with instructors, which allowed for immediate clarification of difficult topics.

This study is also in agreement with Ali and Khan (2019), study titled "synchronous learning in online classrooms: impacts on STEM students' achievement" in Egypt, exploring the effect of real-time online instruction on the academic performance of STEM students. Results indicated that synchronous learning had a significant positive impact on students' achievement in STEM subjects, particularly in enhancing understanding of complex concepts

through interactive problem-solving and immediate feedback from instructors. This was primarily due to the real-time interaction and immediate feedback facilitated by live sessions.

Conclusion

From the result of the data analysis and the findings obtained, students tend to achieve meaningful learning in electrolysis concept when taught with synchronous e-learning than asynchronous e-learning. Therefore, it is concluded that synchronous e-learning enhances students' interest and academic achievement more than asynchronous e-learning.

Recommendations

It was recommended that the National Commission for Colleges of Education should develop the appropriate framework necessary for encouraging the adoption of integration of e-learning platforms such as that of the synchronous and asynchronous instruction. The synchronous e-learning should be integrated into the secondary school science curriculum.

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