



Effects of Blended Learning on Secondary Students' Achievement in Basic Science and Technology for Sustainable Educational Development in Ekiti-State, Nigeria

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Abstract

This research work explores the impact of blended learning (BL) on secondary school learners' achievement in Basic Science and Technology (BST), with an emphasis on fostering sustainable educational development. In educational settings, blended learning which integrate traditional in-person instruction with digital and online resources has grown tremendously offering opportunities to enhance student engagement and improve academic outcomes. The research utilized a quasi-experimental design involving a pre-test, post-test non-randomized control group. The study population included all Junior Secondary School Two (JSS2) Basic Science and Technology learners in Ekiti State. Using a multi-stage sampling technique, a sample of one hundred and twenty students from four schools was selected, with intact classes assigned to either the experimental or control group. The experimental group received instruction through the blended learning approach, while the control group was taught using conventional teaching methods. A researcher-designed instrument, the Basic Science and Technology Achievement Test (BSTAT), was used to assess students' performance in pre-tests and post-tests. The instrument underwent face and content validation to ensure accuracy and relevance. Reliability was confirmed using the test-retest method, yielding a reliability coefficient of 0.85. Data analysis involved the use of mean and standard deviation to address research questions, while Analysis of Covariance (ANCOVA) was employed to test the hypotheses at a 0.05 significance level. The results showed that the experimental post-test group's mean scores differed significantly from the control group, with the experimental group having a better learning outcomes than the control group. Additionally, the study found no significant influence of gender on students' academic achievement when using blended learning. The study concludes that integrating blended learning into the school curriculum can significantly enhance student achievement in Basic Science and Technology. It recommends that teachers adopt blended learning approaches in their instructional delivery to improve student outcomes and promote sustainable educational practices.

Keywords

Blended Learning, Students' Achievement in Basic Science and Technology, Basic Science and Technology, Sustainable development, Education

INTRODUCTION

Blended learning sometimes referred to as hybrid learning combines traditional face-to-face classroom instruction with online and digital learning components to create a more flexible and engaging educational experience. This approach seeks to maximize the benefits of both in-person and virtual environments, allowing learners to access learning materials and complete activities at their own pace, while also engaging in direct, collaborative learning experiences with peers and instructors.

According to Graham, Woodfield, and Harrison (2022), blended learning involves strategically blending synchronous and asynchronous learning activities to optimize student engagement and performance. This model allows students to interact with content in various formats, such as videos, interactive simulations, or online quizzes, in addition to in-class discussions and hands-on activities. Such integration not only takes care of different learning styles but also encourages learners to take responsibility for their learning by utilizing digital tools and resources.

Horn and Staker (2021) highlight that blended learning is characterized by four key elements: flexibility, personalization, accessibility, and student-centeredness. Flexibility allows students to engage with material in diverse formats and at times that best suit their schedules, while personalization helps meet the special learning needs of each student. Blended learning also increases accessibility to quality educational resources, making it especially beneficial in regions or schools with limited educational infrastructure. By emphasizing student-centeredness, it encourages active learning and cultivates self-directed learning skills, which are essential in today's dynamic educational and professional landscape.

A study by Hrastinski (2023) also underscores that blended learning can provide a more inclusive educational experience, supporting students with various learning styles and paces by combining online and in-person instructional approaches. Online learning environments allow for adaptive learning systems that can trace learners' progress, locate areas for improvement, and suggest personalized content to enhance learning outcomes.

Furthermore, Dziuban, Moskal, and Hartman (2022) argue that blended learning contributes to sustainable education by reducing the need for physical resources and allowing for scalable learning experiences. Blended learning models are adaptable across different disciplines, including science and technology, where multimedia tools can simplify complex concepts and foster a better comprehension of subject matter.

Also, Blended learning is a dynamic, learner-centered method that leverages the strengths of both traditional and digital educational methods. By offering flexibility, promoting active learning, and supporting personalized instruction, it has become a significant model for modern education that can be adapted to various educational needs and settings (Graham et al., 2022; Horn & Staker, 2021; Hrastinski, 2023).

In recent years, Blended learning has become as an effective instructional model that combines traditional classroom methods with online and digital resources to enrich the learning experience and enhance student engagement. This model has gained traction as an innovative method to address the evolving aspirations of learners in the twenty first century, where digital literacy and independent learning skills are important (Garrison & Vaughan, 2017). With blended learning, learners are encouraged to put in more responsibility for their personal learning, and educators take care of diverse learning styles and paces, ultimately contributing to improved academic performance, especially in subjects like Basic science and technology (Lim & Morris, 2020).

Several studies have examined the positive influence of BL on learners' academic achievement. According to Owston, York, and Murtha (2019), blended learning environments allow students to interact with course materials both inside and outside the classroom, causing a flexible and adaptive learning environment that aligns with their individual needs. Moreover, research by Bakia, and Murphy (2019) emphasizes that blended learning not only supports deeper learning but also provides students with valuable digital skills that are essential for their future academic and professional pursuits.

Blended learning is particularly relevant to science and technology education, where hands-on experiences and real-world applications are key to understanding complex concepts. Studies like those of Ng and Ng (2021) demonstrate that blended learning approaches, by incorporating multimedia and interactive simulations, can significantly improve students' understanding and retention of scientific concepts. Furthermore, it aligns well with the goals of sustainable educational development by making educational resources more accessible and adaptable to diverse learning needs and socio-economic contexts (Al-Qahtani & Higgins, 2019).

In Nigeria, where educational resources are often limited and class sizes large, Blended learning offers a promising clue to the problems of teaching Basic Science and Technology in secondary schools (Ajayi & Akinola, 2023). Despite this potential, there is still few research on how Blended learning specifically affects secondary school students' achievement in Basic Science and Technology (BST), especially within the Nigerian context. This study, therefore, seeks to fill this gap by exploring the impact of Blended learning on learners' achievement in Basic Science and Technology, with a focus on its implications for sustainable educational development.

Blended learning, which combines traditional in-person instruction with online resources, has emerged as a critical approach in promoting sustainable educational development by enhancing learning outcomes, reducing resource consumption, and fostering digital literacy. Researchers in recent years have highlighted the diverse ways blended learning contributes to educational sustainability, addressing both the quality of learning and the long-term viability of educational practices.

Blended learning has shown equally significant promise in improving student engagement, academic performance, and retention of knowledge. For instance, Graham et al. (2022) note that blended learning environments foster active learning and provide students with greater autonomy, leading to improved academic outcomes. Their research highlights that blended learning not only improves learners' comprehension of complex subjects but also empowers them with critical thinking and problem solving skill essential for sustainable development. Similarly, Hrastinski (2023) emphasizes that blended learning's flexibility allows learners to study educational material at their own pace, increasing their motivation and accountability in the learning process.

One of the essential aspects of sustainable educational development is resource efficiency, and blended learning supports this goal by reducing the need for physical materials and space. Leal Filho et al. (2021) discuss how blended learning's partial reliance on digital resources decreases the environmental impact of education by minimizing paper use, reducing travel needs, and lowering the demand for classroom infrastructure. This shift not only conserves resources but also reduces the carbon footprint associated with traditional education, which aligns with sustainability goals.

Blended learning also plays a vital role in making education more accessible, especially in regions with limited infrastructure. By incorporating online elements, blended learning enables learners from different backgrounds and rural areas to access durable educational resources. Ng and Ng (2021) argue that blended learning reduces geographic and socio-economic barriers to education, helping to promote equitable access to learning opportunities. This increased accessibility supports sustainable educational development by striving to provide education for all, in line with Global Sustainable Development Goals (GSDGs) focused on inclusivity and equal opportunity.

Digital literacy is essential for sustainable development in today's knowledge-based economy, and blended learning encourages the development of these skills. Horn and Staker (2021) argue that students engaged in blended learning gain essential digital skills that are crucial for lifelong learning. As students navigate online platforms and manage digital resources, they develop competencies that will enable them to adapt to technological changes throughout their careers. These skills not only prepare students for future employment but also promote sustainability by fostering a workforce capable of supporting a knowledge-based economy.

Barbier and Burgess (2020) highlight the importance of sustainable practices within education, emphasizing that current educational approaches must adapt to address global challenges like climate change and resource scarcity. Blended learning aligns with these goals by promoting a balanced, eco-friendly, and inclusive educational approach that prepares students to become informed and responsible global citizens.

Therefore this study aims to contribute to the body of knowledge on Blended learning, providing insights that could inform policy makers, educators, and other stakeholders in the education setting. Through this, the study underscores the potential of Blended learning as a tool for achieving educational sustainability, particularly in science and technology education.

PURPOSE OF THE STUDY

This study's main objective is to find out how blended learning affects secondary school students' achievement in Basic Science and Technology in Nigeria. In particular, the study seeks to:

- i. assess how the integration of Blended learning approaches influences learners' comprehension of difficult scientific concepts and their overall academic achievement in Basic science and technology.
- ii. investigate the interactive effects of male and female students when teaching basic science and technology using a blended learning approach.
- iii. identify the challenges and barriers to the effective implementation of Blended learning strategies in Nigerian secondary schools, as well as potential opportunities for improving educational practices.

STATEMENT OF PROBLEM

The rapid improvement of technology and the growing integration of digital tools in education have necessitated a reevaluation of traditional teaching methods. In Nigeria, there is increasing concern about the efficiency of conventional instructional approaches in improving learners' academic achievement, particularly in subjects like Basic science and technology. Many secondary school learners face challenges in grasping complex scientific concepts and demonstrating proficiency in essential technological skills, both of which are critical for their future educational and career success.

Despite the acknowledged benefits of blended learning- a pedagogical model that combines face-to-face instruction with online and digital resources its implementation in Nigerian secondary schools remains inconsistent and limited. Existing research suggests that blended learning can significantly improve student engagement, motivation, and academic performance (Graham et al., 2022; Horn & Staker, 2021). However, there is a notable lack of empirical studies specifically investigating the impact of Blended learning on learners' achievement in Basic science and technology within the Nigerian educational context.

Furthermore, the Nigerian educational system grapples with challenges related to resource allocation, teacher training, and technology access, which can impede the efficient implementation of blended learning strategies. Consequently, there is an urgent need to explore how Blended learning can be efficiently harnessed to improve learners' academic performance in Basic science and technology. This study aims to fill this gap by examining the impact of Blended learning on secondary school learners' achievement in Basic science and technology, focusing on promoting sustainable educational development in Nigeria.

RESEARCH QUESTIONS

The following research questions were raised to guide the study:

- i. Would there be any difference in the mean achievement scores of learners taught with blended strategy and convectional approach in Basic Science and Technology.
- ii. Would there be any interactive effect of male and female learners when exposed to Blended learning instructional strategy in Basic Science and Technology.

RESEARCH HYPOTHESES

Two research hypotheses were formulated and tested

H₀₁: There is no significant main effect of treatment on the academic achievement of learners in Basic Science and Technology.

H₀₂: There is no significant interactive effect of male and female students on the academic achievement when taught with blended learning instructional strategy.

METHODOLOGY

The study employed a quasi-experimental design using a non-randomized pretest, posttest control group approach. The pretest was conducted to establish the baseline knowledge of the students and ensure academic homogeneity between the two groups before the treatment.

The population for the study comprised all Junior Secondary Two (JSS2) Basic Science and Technology students in Ekiti State. A sample of 120 students was selected using a multi-stage sampling technique. In the first stage, four local governments were chosen from the three senatorial districts in Ekiti State. The second stage involved randomly selecting three schools from each selected local government. Finally, 10 students were purposively selected from each school. The selected students were then randomly assigned to experimental and control groups.

The experimental group received instruction using a blended learning approach, which combined Google Classroom with face-to-face teaching, while the control group was taught using conventional teaching methods.

The instrument used for data collection was the Basic Science and Technology Achievement Test (BSTAT), developed by the researcher. The instrument had two sections: Section A gathered the bio data of the respondents, while Section B consisted of 40 multiple-choice questions on topics such as motion, habitat, and basic technology tools. The questions included clear instructions for selecting the correct options.

Two seasoned Basic Science and Technology teachers and specialists in test and measurement validated the instrument. Reliability of the instrument was determined through the test-retest method, yielding a reliability coefficient of 0.85, which was deemed adequate for the study.

The experimental group was taught using the blended learning approach (Google Classroom and face-to-face instruction), while the control group received instruction via the conventional teaching method. Data collected from the pretest and posttest were analyzed statistically using Analysis of Covariance (ANCOVA) and post-hoc analysis to determine the effectiveness of the treatment.

RESULTS

Research Question 1: Would there be any difference in the mean achievement scores of student taught with blended learning technique and convectional approach in Basic science and technology.

Table 1 Mean Achievement scores of students taught using blended learning and convectional method in Basic science and technology

Teaching techniques	N	Pretest		Post test	
		Mean	S.D.	Mean	S.D.
Experimental group (Google classroom and face-to-face)	60	13.86	2.66	25.76	1.69
Conventional group	60	14.06	2.46	12.41	1.76
Total	60	13.86	2.56	19.09	1.73

Table 1 presents the mean achievement scores of two groups of learners taught Basic science and technology using different teaching techniques: a blended learning approach (Google Classroom combined with face-to-face instruction) and a conventional method. The mean pretest score for the experimental group (blended learning) is 13.86 with a standard deviation (S.D.) of 2.66. The conventional group has a similar mean pretest score of 14.06 with an S.D. of 2.46. These pretest scores indicate that both groups had relatively comparable achievement levels in Basic science and technology before the treatment, as the mean scores are close.

However, after the treatment, the experimental group shows a significant increase in the post-test mean score, reaching 25.76 with an S.D. of 1.69. In contrast, the conventional group has a lower post-test mean score of 12.41 with an S.D. of 1.76, indicating minimal improvement compared to the experimental group. The marked difference in post-test scores suggests that the Blended learning approach had a positive effect on student achievement, resulting in higher scores compared to the conventional teaching method. Therefore, the total mean post-test score across both groups is 19.09 with an S.D. of 1.73, which reflects the combined outcome for the two groups. The substantial increase in post-test mean scores for the Experimental group highlights the effectiveness of the blended learning approach in improving learners' achievement in Basic science and technology. Finally, this data shows that students taught using the Blended learning approach (combining Google Classroom and face-to-face instruction) achieved significantly higher post-test scores than those taught through conventional methods. This indicates that Blended learning is more effective in enhancing learners' academic achievement in Basic science and technology.

Research Question 2: Would there be any interactive effect of male and female learners when taught with Blended strategy in Basic science and technology?

Table 2 Mean achievement scores of male and female students taught with Blended learning in Basic science and technology

Gender	N	Pre-test		Post-test	
		Mean	S.D.	Mean	S.D.
Male	23	13.56	2.40	27.69	1.31
Female	37	13.52	2.33	27.74	2.16
Total	60	13.54	2.37	27.72	1.74

Table 2 shows the mean achievement scores of male and female learners taught Basic science and technology using a Blended learning approach, comparing their achievement before and after the treatment. The male learners had a pre-test mean score of 13.56 with a SD of 2.40; while the female learners had a similar pre-test mean score of 13.52 with an S.D. of 2.33. The close pre-test scores for both genders indicate that male and female learners had comparable levels of achievement in Basic science and technology before the blended learning treatment. After the treatment, the male students achieved a mean post-test score of 27.69 with an S.D. of 1.31. While the female learners achieved a similar mean post-test score of 27.74 with a slightly higher S.D. of 2.16. Finally, the data indicates that both male and female learners benefited substantially from the blended learning approach in Basic science and technology, with no significant difference in post-test achievement scores between the genders. This suggests that Blended learning is a gender-neutral strategy that effectively enhances student achievement across both male and female groups.

Research Hypotheses

Hypothesis 1: There is no significant main effect of treatment on the academic achievement of learners in Basic science and technology

Table 3 ANCOVA of students' achievement in Blended learning and the convection groups

Source	SS	Df	MS	F	Sig.(P)	Partial Eta ²
Corrected Model	5348.403	2	2674.201	904.491	.000	.938
Intercept	1303.042	1	1303.042	404.726	.000	.791
Covariate(pretest)	1.728	1	1.728	.586	.445	.005
Group	5345.954	1	5345.954	1808.150	.000	.938
Error	345.922	117	2.956			
Total	49357.000	120				
Corrected total	5694.326	119				

p < 0.05

Table 3 presents the difference in the mean achievement scores of students taught with blended learning and conventional method in Basic Science and Technology. The result shows that computed F-value (1808.150) with degrees of freedom 1 and 117 was statistically significant at *p* < 0.05 level of significance for the groups. The null hypothesis was rejected. This implies that there is significant difference in the mean achievement scores of students taught with blended learning and conventional method in Basic Science and Technology. The treatment accounted for about 93.9% (Eta² = 0.939) of the observed variance in the mean achievement scores of students taught with blended learning and conventional method in Basic Science and Technology. The mean difference among the estimated marginal means descriptive statistics of the groups, after correcting for the other effects in the model is presented in Table 4.

Table 4 Estimated Marginal Means for Treatment on achievement scores of students in Basic Science and Technology

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Blended learning	25.755	.222	25.315	26.195
Control	12.395	.222	11.955	12.835

Table 4 shows that students exposed to blended learning had higher estimated marginal means score on achievement in Basic Science than their counter parts in the conventional group. The result further shows that there was significant mean difference between achievement mean score of students when subjected to blended learning instructional strategy with (mean for peer-tutoring = 25.755) and (mean for conventional = 12.395).

Hypothesis 2: There is no significant interactive effects of male and female on the academic achievement of learners expose to blended learning instructional technique.

Table 5 ANCOVA for interactive effect of male and female on academic achievement of learners exposed to blended learning strategy in Basic Science and Technology

Source	SS	Df	MS	F	Sig.	Partial Eta ²
Corrected Model	3.121	2	1.561	.542	.586	0.19
Intercept	1227.888	1	1227.889	426.428	.000	.883
Covariate(Pretest)	2.883	1	2.883	1.001	.321	.017
Gender	.867	1	.867	.301	.586	.005
Error	164.130	57	2.878			
Total	39951.001	60				
Corrected Total	167.251	59				

p > 0.05

Table 5 presents the difference in the mean achievement scores of male and female students taught with blended learning instructional strategy in Basic Science and Technology. The result shows that computed F-value (0.301) with degrees of freedom 1 and 57 was not statistically significant at $p > 0.05$ level of significance for the groups. The null hypothesis was accepted. This implies that there is no significant difference in the mean achievement scores of male and female students taught with blended learning strategy in Basic Science and Technology. Less than 1% ($\text{Eta}^2 = 0.005$) of the observed variance in the mean achievement scores of students taught with blended learning in Basic Science and Technology was explained by gender.

DISCUSSION OF FINDING

Table 1 showed that learners exposed to blended learning significantly improved in their post-test scores compared to their peers taught utilizing conventional methods. This was further supported by table 4, where the estimated marginal mean analysis confirmed that the blended learning group achieved higher scores than the control group, indicating the effectiveness of this strategy. These findings are consistent with studies by Graham, Woodfield, and Harrison (2022), who found that Blended learning positively impacts student engagement and academic performance by offering diverse, interactive learning experiences. Similarly, Hrastinski (2023) emphasized that Blended learning enables better retention and comprehension by allowing students to interact with content both in-class and online, making complex subjects more accessible. The outcome of this study supports these claims, showing that blended learning enhances understanding in subjects like Basic Science and Technology by utilizing a multi-faceted approach.

In Table 2, both male and female learners taught using blended learning demonstrated similar improvements in academic achievement, as evidenced by nearly identical post-test scores. Table 5 further reinforced that gender did not have a statistically significant effect on academic outcomes, suggesting that blended learning is equally effective for both male and female learners. This gender neutrality aligns with research from Lim and Morris (2020), who observed that blended learning environments provide equal opportunities for all students to participate and succeed, reducing traditional gender disparities in academic performance. Horn and Staker (2021) also noted that Blended learning can democratize learning by catering to diverse learning styles, which benefits all genders equally. This study's finding that blended learning has a consistent positive impact across gender lines supports the assertion that it is an inclusive educational strategy, promoting equitable outcomes for all students.

Also, table 3 demonstrated a highly significant main effect of Blended learning on learners' academic achievement in Basic science and technology, with the teaching method accounting for a substantial proportion of the variance in students' scores. This suggests that blended learning is markedly more effective than conventional teaching approaches. The substantial positive influence of blended learning on academic achievement aligns with Garrison and Vaughan's (2017) findings that Blended learning causes better learning and deeper academic success by combining face-to-face instruction with online interaction. Bakia and Murphy (2019) also found that blended learning significantly improves academic outcomes by providing students with more personalized and accessible learning experiences. The results of this study, showing a strong positive effect of blended learning on science and technology achievement, add to the evidence that this instructional method enhances students' academic success.

Findings across both Table 3 and Table 5, pre-test scores showed minimal impact on students' post-test achievement. This suggests that initial knowledge levels did not significantly affect the positive outcomes observed after the blended learning intervention, reinforcing the strategy's ability to support students regardless of their starting knowledge base.

This finding aligns with Purvis et al. (2019), who reported that blended learning reduces dependency on students' initial knowledge levels, offering each student the flexibility to progress according to their pace and needs. Leal Filho et al. (2021) similarly highlighted that blended learning supports varied learner backgrounds and achievement levels, making it effective in improving outcomes across a diverse student population. The limited influence of pre-test scores in this study reinforces the flexibility and adaptability of Blended learning as an instructional approach.

The findings from this study align closely with the body of literature supporting the adoption of Blended learning as a powerful tool for improving educational outcomes across diverse student groups. By enhancing academic achievement, providing equitable learning opportunities across genders, and minimizing the impact of pre-existing disparities, blended learning supports sustainable educational development goals. The results align with Hrastinski (2023)

and Leal Filho et al. (2021), who advocate for blended learning as a pathway to foster lifelong learning skills and digital literacy, essential components of a sustainable education system.

CONCLUSION

This study demonstrates that blended learning significantly improves learners' achievement in Basic science and technology, highlighting its potential as an effective instructional approach within Nigerian secondary schools. The substantial gains in post-test scores suggest that blending traditional face-to-face instruction with digital resources enhances academic performance by engaging students more deeply and facilitating better retention and understanding of scientific concepts.

Additionally, the findings show that Blended learning is equally beneficial for male and female students, supporting its value as an inclusive educational strategy. The minimal variation in pre-test and post-test scores across gender and prior knowledge further indicates that blended learning can adapt to diverse learning needs, promoting equitable access to quality education.

Aligned with sustainable development goals, blended learning offers a pathway to build digital literacy, critical thinking, and lifelong learning skills. To fully realize its benefits, however, schools must address issues related to resources, teacher training, and technological access. Successfully implementing blended learning in Nigeria and similar educational contexts can drive sustainable educational development, equipping students with skills essential for a technology-driven future. These findings provide a basis for future research to refine blended learning approaches and evaluate their long-term impact on student performance across different subjects.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. Educational policymakers and school administrators should consider incorporating blended learning into the curriculum for subjects like Basic Science and Technology, where complex concepts can benefit from interactive, digital resources alongside traditional instruction.
2. Teachers should be provided with regular training and support to develop the skills needed to effectively implement blended learning strategies. This training should focus on integrating digital tools with face-to-face teaching to enhance student engagement and understanding.
3. Schools should invest in the important technological infrastructure to support Blended learning, including reliable internet access, digital devices, and software for both students and teachers. Adequate funding and resource allocation are germane to ensure that all learners can benefit from this approach.
4. To promote inclusivity, educational institutions should strive to make blended learning accessible to all students, regardless of socioeconomic background or gender. This may involve providing additional resources or support for students with limited access to technology outside the classroom.
5. Researchers should conduct longitudinal studies to x-ray the long-term influence of Blended learning on academic achievement across various subjects and educational levels. Additionally, studies exploring how BL can be made use of to fit the unique challenges of different educational contexts will provide valuable insights for broader application.
6. Educational leaders and policymakers should view blended learning as a pathway to achieve sustainable educational development by fostering digital literacy and critical thinking skills. Integrating sustainable development principles into the curriculum through blended learning can help prepare students for the demands of a rapidly evolving global economy.

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