Integration and Effectiveness of Blended Learning in STEAM Education among Senior Secondary Schools in Federal Capital Territory, Nigeria

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Abstract: This study investigated the integration and effectiveness of blended learning in Science, Technology, Engineering, Arts and Mathematics (STEAM) Education among senior secondary schools in the Federal Capital Territory (FCT), Nigeria. Blended learning, which integrates traditional face-to-face instruction with digital technologies, is increasingly recognized as a strategy to enhance teaching and learning outcomes. The study examined teachers' and students' perceptions of blended learning, the extent of technology integration in classrooms by teachers, challenges faced during implementation, and the impact of blended learning on students' engagement and academic performance. A descriptive survey design was adopted, and data were collected using structured questionnaires on four-point and five-point scales administered to a sample of senior secondary school teachers and students in two (2) selected schools in FCT. The selected schools are in Gwagwalada and Abuja Municipal Area Councils. Three hundred and ninety-five (395) students and 39 teachers were sampled for the study. The findings revealed a moderate level of blended learning integration by teachers in their teaching practices. While both teachers and students agree that blended learning is effective in teaching and learning, challenges such as teacher gender imbalance in favour of female teachers, limited number of science-related teachers, limited time to prepare digital content, technical issues disrupting blended learning sessions and limited digital devices for students. The study concluded that for blended learning to be fully effective in FCT senior secondary schools, there must be strategic investment in technological infrastructure, continuous professional development for teachers, and policy support. Some recommendations, among others, were made such as the government should address teacher gender imbalance by launching targeted recruitment drives to attract male STEAM educators and promote gender-neutral hiring policies to ensure balanced representation; Government should rebalance STEAM subject expertise by sponsoring teacher training programmes in engineering, technology and mathematics; Stakeholders should provide teachers with curated digital repositories to reduce preparation burden on the teachers.

Keywords: STEAM, Blended Learning, Technology, Integration, Pedagogy.

Introduction

The education system in Nigeria, like many other developing countries, faces persistent challenges in adapting to contemporary global trends in teaching and learning. One of the most significant transformations in education globally is the shift towards the integration of technology, particularly through blended learning, which combines traditional face-to-face instruction with online digital tools. This shift has become more critical with the increasing emphasis on Science, Technology, Engineering, Arts, and Mathematics (STEAM) education, a model that promotes interdisciplinary learning and prepares students for complex problem-solving in the 21st century (Smith, 2021). In response to these global trends, the Nigerian government has enacted policies to integrate technology into its educational system, particularly through the adoption of STEAM education.

The Nigerian government has recognized the critical role of technology in transforming education. The National Policy on Education (2014) emphasizes the integration of Information and Communication Technology (ICT) at all levels of education. More recently, policies like the National Digital Economy Policy and Strategy (2020) aim to create a digitally inclusive society. These

policies encourage schools to adopt technology-driven pedagogical approaches, including blended learning, to enhance educational outcomes (Federal Ministry of Education, 2020). Furthermore, STEAM education has been introduced into the Nigerian curriculum to align with global education trends that emphasize innovation and creativity through interdisciplinary learning (Akintunde & Nwafor, 2021).

The introduction of STEAM education necessitates significant adjustments to the Nigerian secondary school curriculum. These adjustments aim to promote the development of critical thinking, creativity, and problem-solving skills among students, aligning with the demands of the Fourth Industrial Revolution. In Nigerian secondary schools, particularly in FCT Abuja, curriculum adjustments have included the incorporation of technology and hands-on learning projects in STEAM subjects (Ogunleye, 2022). However, despite these reforms, the implementation of STEAM education remains at an early stage, with significant disparities in resources, teacher training, and infrastructure (Aina, 2022).

In FCT, the adoption of STEAM education varies widely across senior secondary schools. While some schools have begun incorporating STEAM-related content, others struggle due to inadequate resources, lack of teacher training, and poor access to technology (Eze, 2021). Studies suggest that the success of STEAM education depends heavily on the availability of well-trained teachers and infrastructure, both of which are limited in many public schools in Abuja (Kalu, 2023). This uneven implementation highlights the need for more effective strategies, such as blended learning, which can help address some of these challenges.

Traditional teaching methods in Nigerian schools, characterized by teacher-centered instruction and rote learning, are increasingly seen as inadequate for addressing the needs of 21st-century learners. These methods often fail to engage students meaningfully or promote critical thinking and problem-solving skills. As a result, many students struggle to retain knowledge or apply it in real-world contexts (Abdulkarim & Jaja, 2020). The limitations of these traditional methods underscore the need for innovative pedagogical approaches that can enhance students' engagement and learning outcomes.

Blended learning offers a promising solution to the challenges posed by traditional teaching methods. By combining face-to-face instruction with online learning, blended learning allows for greater flexibility, individualized instruction, and the use of diverse educational resources. Research shows that blended learning can enhance students' engagement, improve retention of knowledge, and support personalized learning pathways (Murtala et al,2021). Olibie and Ezeoba (2019), declared higher retention, motivation, and academic performance among students exposed to blended learning compared to those in traditional classroom settings. Blended learning, which combines traditional face-to-face instruction with online learning, has gained popularity in recent years (Garrison & Kanuka, 2004). This approach offers flexibility and personalization, allowing students to learn at their own pace (Dziuban et al., 2004). Research evidence has shown that blended learning can improve student outcomes, including increased engagement and motivation (Garrison & Kanuka, 2004). However, it also presents challenges, such as technical issues and equity concerns (Boelens et al., 2017).

Moreover, the COVID-19 pandemic highlighted the importance of technology in education and accelerated the adoption of blended learning globally. Yusuf and Onasanya (2020), reported growing awareness of blended learning in Nigerian secondary schools despite infrastructure challenges. In the Nigerian context, particularly in FCT, where educational challenges are compounded by overcrowded classrooms and limited resources, blended learning presents a viable solution for improving educational outcomes (Ajiboye, 2022). Ololube et al. (2015) emphasized that sustainable e-learning environments require adequate ICT infrastructure and support.

The outbreak of COVID-19 compelled the Federal Capital Territory (FCT) administration to explore alternatives to the conventional face-to-face mode of teaching and learning. In response, a multimedia educational platform was developed to facilitate remote instruction. This platform enables teachers to prepare and upload lesson content online, while students gain access to a digital library containing a wide range of educational resources. Additionally, the platform supports electronic result management and evaluation processes conducted by Heads of Departments, school principals, and officials from the Quality Assurance Department. As of 2nd June 2025, the platform hosts approximately 525,913 lesson plans, 46,622 lesson notes, 29,704 schemes of work, and 13,571 timetables. These figures continue to change dynamically at a rate of 0.03% to 0.07% per hour, excluding timetable adjustments (Source: FCTEMIS, www.fctemis.org).

However, Binder (2024) identified seven top challenges students face with online teaching. Among them are: Isolation, feeling disconnected, lack of self-discipline by students, time management, distraction, technical issues etc.

This study is significant for several stakeholders. For the government, it provides insights into the effectiveness of current policies and the implementation of technology in education, helping to identify gaps and areas for improvement. For private individuals and educators, the findings offer practical recommendations on how blended learning can be used to enhance teaching and learning in secondary schools. Finally, for researchers, this study contributes to the growing body of literature on the integration of blended learning in the Nigerian educational system, providing a foundation for future studies.

Several studies have examined the integration and effectiveness of blended learning in education. For instance, Adegoke (2021) found that blended learning significantly improved students' academic performance in mathematics in Lagos State secondary schools. In addition, Abdullahi Ali Almarzuqi and Hamida Mat (2024) observed that blended learning, integrating online digital resources with traditional classroom instructions promises to change educational landscape.

The integration of blended learning in STEAM education presents a transformative opportunity for Nigerian secondary schools. However, it comes with its numerous challenges as pointed out by Alabi, Oyewole and Okemakinde (2024). They identified infrastructural limitations, internet costs, lack of ICT skills, accessibility issues, initial high cost, technical issues, pedagogical integration challenges, resistance to change and inadequate training as major barriers to integration of blended learning in Nigerian secondary schools.

Despite the Nigerian government's policies promoting the integration of technology and the introduction of STEAM education, the implementation of blended learning in senior secondary schools, particularly in FCT, remains inadequate.

Several schools lack the infrastructure, resources, and trained personnel necessary to effectively combine traditional and digital learning methods. Consequently, many students in FCT are still being taught through conventional, teacher-centered approaches, which have been found to limit engagement, critical thinking, and overall academic performance.

Moreover, while studies have been conducted on the impact of blended learning in various regions, there is a gap in research focusing on the specific challenges and effectiveness of this teaching method in STEAM education within FCT senior secondary schools. Understanding the current state of blended learning implementation and its potential benefits in this context is critical for developing targeted interventions that align with the educational demands of the 21st century.

This study assessed the current state of blended learning in FCT to identify the challenges faced, and provide recommendations for effective implementation. This study is crucial for identifying gaps in the current integration of blended learning in senior secondary schools in FCT, Abuja. By highlighting teachers' and students' experiences, it provides policymakers, educators, and stakeholders with valuable insights into improving the implementation and effectiveness of blended learning in Nigeria. The findings will guide policymakers in making informed decisions, support educators in adopting innovative teaching strategies, and contribute to the body of knowledge on STEAM education and technology integration in Nigeria. The outcome of this study will provide recommendations for addressing the challenges faced by schools in adopting technology-enhanced learning approaches.

Embarking on this research is important for providing empirical evidence on the effectiveness of blended learning in improving educational outcomes in FCT senior secondary schools. It is upon this background that this study was carried out to determine the extent of integration, and effectiveness of blended learning in STEAM education in Senior Secondary Schools in FCT.

Purpose of the Study

The main purpose of the study was to assess the extent of integration and effectiveness of blended learning in STEAM education in senior secondary schools in FCT. Specifically, the objectives were to:

i. Examine the extent to which teachers integrate blended learning into their teaching practices in senior secondary schools in FCT.

ii. Determine teachers' perception regarding the effectiveness of blended learning in enhancing teaching and learning in senior secondary schools in FCT.

iii. Investigate students' perception on the effectiveness of blended learning in improving their engagement in STEAM subjects in senior secondary schools in FCT.

iv. Investigate students' perception on the effectiveness of blended learning in improving their academic performance in STEAM subjects in the senior secondary schools in FCT.

v. Identify the challenges faced by teachers in the implementation of blended learning in senior secondary schools in FCT.

vi. Identify the challenges faced by students in the implementation of blended learning in senior secondary schools in FCT.

Research Questions

The following research questions guided the study:

1. To what extent do teachers integrate blended learning into their teaching practices in senior secondary schools in FCT?

2. What is the perception of teachers regarding the effectiveness of blended learning in enhancing teaching and learning in senior secondary schools in FCT?

3. What is the perception of students on the effectiveness of blended learning in improving their engagement in STEAM subjects in senior secondary schools in FCT?

4. What is the perception of students on the effectiveness of blended learning in improving their academic performance in STEAM subjects in senior secondary schools in FCT?

5. What are the challenges faced by teachers in the implementation of blended learning in senior secondary schools in FCT?

6. What are the challenges faced by students in the implementation of blended learning in senior secondary schools in FCT?

Null Hypotheses:

The following null hypotheses were tested at $\alpha = 0.05$ level of significance:

➢ **H_{01}:** There is no significant difference in the extent to which male and female teachers integrate blended learning into their teaching practices in senior secondary schools in FCT.

➢ **H_{02}:** There is no significant difference in teachers' perception regarding the effectiveness of blended learning in enhancing teaching and learning with respect to area of specialization in senior secondary schools in FCT.

➢ **H_{03}:** There is no significant difference in perception of male and female students regarding the effectiveness of blended learning in improving their engagement in STEAM subjects in senior secondary schools in FCT.

Methodology

The study adopted a descriptive survey design. This design is appropriate because it allows for a comprehensive analysis of the integration and effectiveness of blended learning from both teachers' and students' perceptions. The target population of the study included 4,202 teachers and 32,514 senior secondary two (SS2) students from public schools in FCT during the 2024/2025 academic session (FCT Education Management and Information System (EMIS).

Simple random sampling was used to select two area councils (Abuja Municipal Area Council (AMAC) & Gwagwalada) out of the six area councils in FCT. One public senior secondary school was selected from each of the two area councils. Thirty-nine (39) teachers and three hundred and ninety-

five (395) students formed the sample of the study using Taro Yamane formula.

Structured questionnaires were employed to collect data from both students and teachers. The instruments were four-point scale of Strongly Agree (SA)=4, Agree (A)=3, Disagree (D)=2, Strongly Disagree (SD)=1 and five-point scale of Not at All (NA)=1, Minimally (MI)=2, Moderately (MO)=3, Considerably (CO)=2, and Extremely (EX)=5 to capture respondents' extent of integration of Blended learning in their teaching practices, perception on Blended learning and challenges being faced in using Blended learning as seen in the result tables. The decision rule for the four-point scale questionnaire is 2.5 while that of five-point scale is 3.0. The instruments were validated by experts in mathematics education, statistics and educational measurement and evaluation. Thirty (30) copies of the questionnaires were administered to the students and the teaching staff of a senior secondary school not included in the study sample for the pilot testing. The Cronbach's alpha for internal consistency was used. The Cronbach Alpha values of the students' and teachers'

questionnaires were found to be 0.86 and 0.81, which are higher than 0.7 considered acceptable for research purposes. Creswell, J.W. (2014).

Given the ordinal nature of the data obtained from the questionnaires, appropriate statistical tools such as frequencies, percentages, and mean ranks were employed to summarize the responses and provide an overview of teachers' and students' perception. Additionally, the Mann-Whitney U-test was used to evaluate the null hypotheses.

Results

The following are the analyses of the data collected to provide answers to the research questions posed for the study. $\bar{x}$ and **Std** are used in the tables below to stand for mean and standard deviation respectively.

Research Question 1: To what extent do teachers integrate blended learning into their teaching practices in senior secondary schools in FCT?

Table 1: Extent of Integration of Blended Learning into Teaching

S/N	VALUE	1	2	3	4	5	$\bar{x}$	Std	Decision
1	To what extent do you use technology to prepare lesson plan?	2	3	11	14	9	3.64	1.09	ACCEPT
2	To what extent do you incorporate multimedia (video presentations) into your lessons?	8	14	6	10	1	2.54	1.17	REJECT
3	To what extent do you use online learning platforms to share materials with students?	3	9	17	6	4	2.97	1.06	REJECT
4	To what extent do your students regularly use technology during class activities?	14	11	8	4	2	2.21	1.20	REJECT
5	To what extent do you use technology to assess students learning outcomes?	10	11	10	6	2	2.46	1.19	REJECT
6	To what extent do you integrate technology into both practical and theoretical lessons?	2	12	13	9	3	2.97	1.04	REJECT
7	To what extent do you encourage students to use technology for assignments?	0	4	14	16	5	3.56	0.85	ACCEPT
8	To what extent do you use educational apps and software to assist students in learning?	2	8	17	10	2	3.05	0.94	ACCEPT
9	To what extent has your teaching style changed positively with the integration of technology?	2	3	10	15	9	3.67	1.08`	ACCEPT
	Grand Mean						**2.91**	**1.07**	**REJECT**

Table 1 shows that the grand mean is 2.91<3.00 which indicates that the teachers do not integrate blended learning into teaching in senior secondary school to a large extent.

Research Question 2: What is the perception of teachers regarding the effectiveness of blended learning in enhancing teaching and learning in senior secondary schools in FCT?

Table 2: Teachers' Perception Regarding the Effectiveness of Blended Learning

S/N	VALUE	1	2	3	4	$\bar{x}$	Std	Decision
1	Blended learning enhances my ability to engage students in senior secondary schools.	2	6	17	14	3.10	0.85	AGREE
2	Blended learning improves my teaching effectiveness in senior secondary schools.	4	7	16	12	2.92	0.96	AGREE
3	Blended learning helps me to assess students' learning outcomes better.	3	8	14	14	3.00	0.95	AGREE
4	Blended learning provides me with useful insights into students' learning needs.	3	3	17	16	3.18	0.89	AGREE
5	Blended learning enables me to personalize instruction for students.	3	6	21	9	2.92	0.84	AGREE
6	Blended learning increases my ability to track students' progress.	2	7	22	8	2.92	0.77	AGREE
7	Blended learning enhances my interaction with students.	3	4	20	12	3.05	0.86	AGREE
8	Blended learning helps me to identify areas where	4	4	17	14	3.05	0.94	AGREE

S/N		1	2	3	4	$\bar{x}$	Std	Decision
	students need additional support.							
9	Blended learning increases my confidence in using technology.	2	4	21	12	3.10	0.79	AGREE
10	Blended learning is an effective way to enhance students' learning outcomes.	3	3	16	17	3.21	0.89	AGREE
	Grand Mean					**3.05**	**0.87**	**AGREE**

Table 2 shows that the grand mean is 3.05>2.50 which indicates that the teachers agree with the perception regarding the effectiveness of Blended Learning in senior secondary school in FCT.

Research Question 3: What is the perception of students on the effectiveness of blended learning in improving their engagement in STEAM subjects in senior secondary schools in FCT?

Table 3: Students' Perception on the effectiveness of blended learning in improving their engagement in STEAM subjects

S/N	VALUE	1	2	3	4	$\bar{x}$	Std	Decision
1	I enjoy using technology in my lessons.	27	25	144	199	3.3	0.87	AGREE
2	Online and face-to-face learning makes learning more interesting.	15	43	168	169	3.24	0.79	AGREE
3	I am more engaged when lessons include both online and classroom activities.	16	52	134	193	3.28	0.84	AGREE
4	I am more motivated to complete online assignments.	38	69	154	134	2.97	0.95	AGREE
5	I use online resources to learn outside the classroom.	22	68	129	176	3.16	0.90	AGREE
6	Online learning allows me to interact better with my teachers.	38	93	138	126	2.89	0.96	AGREE
7	I prefer classes where I can use digital tools.	17	45	140	193	3.29	0.83	AGREE
8	I find lessons more interactive with the use of technology.	19	60	123	193	3.24	0.88	AGREE
9	I feel more confident participating in online learning activities.	26	74	146	149	3.06	0.91	AGREE
10	Online learning allows me to work at my own pace.	22	63	145	165	3.15	0.88	AGREE
11	I prefer online to face-to-face learning.	54	115	110	116	2.73	1.03	AGREE
	GRAND MEAN					**3.12**		**AGREE**

Table 5 shows that the observed grand mean =3.12 > 2.5, the hypothetical mean. Hence, the result reveals that students generally agree on the effectiveness of Blended Learning in enhancing their engagement in STEAM subjects.

Research Question 4: What is the perception of students on the effectiveness of blended learning in improving their academic performance in STEAM subjects in senior secondary schools in FCT?

Table 4: Students' perception in the effectiveness of blended learning in improving their academic performance in STEAM subjects

S/N	VALUE	1	2	3	4	$\bar{x}$	Std	Decision
1	Online learning has improved my performance in science-related subjects.	25	75	161	134	3.02	0.89	AGREE
2	I understand school subjects better with the use of digital tools.	17	55	175	148	3.15	0.82	AGREE
3	Online with face-to-face learning help me prepare better for tests.	16	63	176	140	3.11	0.82	AGREE
4	I score higher on assessments when digital resources are used.	15	65	134	181	3.22	0.85	AGREE
5	I learn faster with a combination of face-to-face and online lessons.	24	55	137	179	3.19	0.90	AGREE
6	Online learning supports me in completing assignments better.	22	48	148	177	3.22	0.87	AGREE
7	I remember lessons better when I study using digital and face-to-face learning.	34	50	128	183	3.16	0.95	AGREE
8	Online learning helps me understand difficult topics better.	29	58	137	171	3.14	0.93	AGREE
9	I feel confident in my academic progress due to online and face-to-face learning.	23	35	164	173	3.23	0.84	AGREE
10	My performance has improved since online and face-to-face learning was introduced.	32	57	126	180	3.15	0.95	AGREE
	Grand Mean					**3.16**		**AGREE**

Table 4 indicates that students generally agree that Blended Learning enhances effectiveness in improving their academic performance in STEAM subjects since the observed grand mean=3.16>2.50.

Research Question 5: What are the challenges faced by teachers in the implementation of blended learning in senior secondary schools in FCT?

Table 5: Challenges Teachers Faced in the Application of Blended Learning

S/N	VALUE	1	2	3	4	$\bar{x}$	Std	Decision
1	I lack access to necessary digital tools.	9	9	14	7	2.49	1.05	DISAGREE
2	Internet access is unavailable in my school.	11	13	5	10	2.36	1.16	DISAGREE
3	I have limited time to prepare digital content.	4	17	11	7	2.54	0.91	AGREE
4	Students face difficulty accessing online materials.	6	12	15	6	2.54	0.94	AGREE
5	Technical issues disrupt my blended learning sessions.	4	14	18	3	2.51	0.79	AGREE
6	Many students lack personal devices for online learning.	7	2	17	13	2.92	1.06	AGREE
7	Blended learning increases my workload.	7	20	8	4	2.23	0.87	DISAGREE
8	I lack sufficient training in using educational technologies.	6	16	13	4	2.38	0.88	DISAGREE
9	Students struggle with self-discipline in online tasks.	2	13	18	6	2.72	0.79	AGREE
10	There is insufficient technical support for blended learning in my school.	6	9	15	9	2.69	1.00	AGREE
	Grand Mean					**2.54**	**0.95**	**AGREE**

From Table 5, the teachers generally agreed with all the challenges mentioned in the questionnaires with the grand mean of 2.54>2.5. However, items 1, 2, 7 and 8 had mean scores less than 2.5.

Research Question 6: What are the challenges faced by students in the implementation of blended learning in senior secondary schools in FCT?

Table 6: Challenges faced by the students' using Blended Learning

S/N	VALUE	1	2	3	4	$\bar{x}$	Std	Decision
1	Sometimes I don't understand how to use online learning tools.	69	85	146	95	2.68	1.03	AGREE
2	I do not always have access to a phone or computer.	69	111	112	103	2.63	1.05	AGREE
3	Internet connection is poor in my area.	88	130	107	70	2.40	1.02	DISAGREE
4	I find it hard to focus during online learning.	86	107	105	97	2.54	1.09	AGREE
5	I prefer face-to-face learning because it's easier to follow.	46	77	131	141	2.93	1.01	AGREE
6	I don't get help easily when using online tools.	70	120	110	95	2.58	1.04	AGREE
7	I get distracted when using phones for learning.	60	94	133	108	2.73	1.03	AGREE
8	Some apps or websites are difficult to use.	63	90	137	105	2.72	1.03	AGREE
9	I don't feel confident asking questions online.	93	125	102	75	2.40	1.05	DISAGREE
10	I sometimes forget or miss online assignments.	67	100	130	98	2.66	1.03	AGREE
	Grand Mean					**2.63**		**AGREE**

Table 6 shows that the observed grand mean is 2.63>2.50 which indicates that the students agree with all the challenges listed in the questionnaire with the exception of poor internet connection in their area and not feeling confident to ask questions online.

Test of Hypotheses

The following are the results of the null hypotheses which were tested at $\propto= 0.05$ level of significance.

H_{01}: There is no significant difference in the extent to which male and female teachers integrate blended learning into their teaching practices in senior secondary schools in FCT.

Table 7: Mann-Whitney U-Test of Significant difference in the extent of technology integration between male and female teachers

Test Statistics				Mann-Whitney U	Asymp. Sig. (2-tailed)	Exact Sig. [2*(1-tailed Sig.)]
Gender	**N**	**Mean Rank**	**Sum of Ranks**	128.500	.828	.831
Male	9	20.72	186.50			
Female	30	19.78	593.50			
Total	39					

The table above indicate that the p=0.831>0.05. Hence, we do not reject the null hypothesis and conclude that there is no significant difference in the extent to which male and female teachers integrate blended learning into their teaching practices in senior secondary schools in FCT.

H$_{02}$: There is no significant difference in teachers' perceptions regarding the effectiveness of blended learning in enhancing teaching and learning with respect to area of specialization in senior secondary schools in FCT.

Table 8: Kruskal-Wallis H Test of Significant difference in teachers' perceptions regarding the effectiveness of blended learning in enhancing teaching and learning with respect to area of specialization

Test Statistics			Kruskal-Wallis H	df	Asymp. Sig.
Gender	**N**	**Mean Rank**	2.615	3	.455
Science	7	24.21			
Technology	2	18.25			
Arts	27	19.96			
Mathematics	3	11.67			
Total	39				

From the table above, we do not reject the null hypothesis, since p=0.455 > 0.05 and thus conclude that there is no significant difference in teachers' perceptions regarding the effectiveness of blended learning in enhancing teaching and learning with respect to area of specialization in senior secondary schools in FCT.

H$_{03}$: There is no significant difference in the perception of male and female students regarding the effectiveness of blended learning in improving their engagement in STEAM subjects in senior secondary schools in FCT.

Table 7: Mann-Whitney U-Test of Significant difference in the extent of technology integration between male and female teachers

Test Statistics				Mann-Whitney U	Asymp. Sig. (2-tailed)
Gender	**N**	**Mean Rank**	**Sum of Ranks**	17609.000	.284
Male	160	205.44	32871.000		
Female	235	192.93	45339.00		
Total	395				

From the table above, since p =0.284>0.05, we do not reject the null hypothesis and conclude that there is no significant difference in the perception of male and female students regarding the effectiveness of blended learning in improving their engagement in STEAM subjects in senior secondary schools in FCT.

Discussion of Results

Findings indicated that teachers do not fully integrate blended learning into their teaching practices as shown in Table 1. However, they moderately use technology to prepare lesson notes, encourage students to complete assignments using digital tools, and utilize educational apps. Teachers acknowledged a moderate positive impact of technology on their teaching styles. No significant gender-based differences were found in the extent of integration. Additionally, Table 2 showed that teachers generally agree on the effectiveness of blended learning in enhancing teaching and learning. The findings also revealed no significant difference in perception across various subject specializations.

The findings have also revealed that students generally agreed that blended learning enhances their engagement in STEAM subjects as indicated in Table 3. The analysis also showed no significant difference between male and female students' perceptions of the effectiveness of blended learning on engagement in STEAM subjects. Table 4 indicated a similar trend, with a grand mean of 3.16, suggesting that students generally agreed that blended learning improves their academic performance in STEAM subjects.

Findings of the study also highlighted teachers' perception of the challenges of blended learning as revealed in Table 5. Most teachers disagreed that they lack access to necessary digital tools or internet connectivity. They also disagreed that blended learning increases their workload or that they lack sufficient training in educational technology. Table 6 revealed that students agreed with the prevalence of most challenges associated with blended learning. However, they did not consider poor internet connectivity or lack of confidence in asking questions online to be significant challenges. This suggests that internet access is relatively stable in their schools and that students are comfortable with online communication. These findings align with Yusuf and Onasanya (2020), who reported growing awareness of blended learning in Nigerian secondary schools despite infrastructural challenges. Similarly, it agrees with Ololube et al. (2015) on having a sustainable e-learning environment with adequate ICT infrastructure and support. Teachers also reported that students struggle with self-discipline in online learning environments. This observation supports the findings of Binder (2024), who identified self-discipline as one of the key challenges in student online learning experiences.

Overall, both teachers and students appreciate the flexibility and accessibility provided by blended learning. Many students find digital platforms beneficial for self-paced learning and reviewing complex topics. Teachers, however, expressed concern about insufficient technical support, echoing the findings of Alabi, Oyewole, Okemakinde (2024), who identified infrastructural limitations, internet costs, and lack of ICT skills as major barriers in Nigerian secondary schools.

Blended learning appears to have a positive impact on student engagement and academic performance when effectively implemented. Students in blended environments show improved content interaction and greater autonomy in learning. However, its overall impact is still constrained by unequal access and implementation challenges. This observation is supported by Olibie and Ezeoba (2019) who reported higher retention, motivation, and academic performance among students exposed to blended learning compared to those in traditional classroom settings.

Despite these positive outcomes, teachers in FCT public senior secondary schools noted that blended learning has not been fully integrated into their teaching practices. Many cited insufficient training, limited access to digital tools, and lack of infrastructure as persistent barriers. Nevertheless, they acknowledged improvements brought by blended learning in certain aspects of teaching (notably items 1, 7, 8, and 9 in the questionnaire).

The findings indicate a strong consensus among teachers regarding the effectiveness of blended learning as an instructional approach. They reported that the integration of face-to-face and digital methods improved student engagement, learning outcomes, and instructional flexibility. Blended learning was also found to support differentiated instruction and help meet diverse student needs. The unanimous agreement suggests growing acceptance of technology-enhanced learning and increasing teacher readiness to adopt innovative practices.

With ongoing improvements in internet connectivity and students' familiarity with digital communication tools, more learners are overcoming traditional barriers such as shyness and are participating more confidently in online discussions.

Conclusion

The findings of this study highlight a moderate but growing adoption of blended learning in senior secondary schools across the Federal Capital Territory (FCT), Nigeria. Both teachers and students generally expressed positive perceptions of blended learning, recognizing its potential to enhance engagement, promote flexibility, and support learner-centered instruction.

However, the successful implementation of blended learning depends on strategic investments in digital infrastructure, sustained teacher training, and equitable access to technology. Without resolving these foundational issues, many students may continue to miss out on the full benefits of blended learning.

Recommendations

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

1. The government should address teacher gender imbalance by launching targeted recruitment drives to attract male STEAM educators and promote gender-neutral hiring policies to ensure balanced representation.
2. Government should rebalance STEAM subject expertise by sponsoring teacher training programmes in engineering, technology and mathematics (prioritizing hands-on digital skills).
3. The government through the Ministry of Education should institutionalize blended learning frameworks by providing school-wide blended learning policy with clear guidelines requiring minimum thresholds for blended activities.
4. Stakeholders in education should provide teachers with curated digital repositories to reduce preparation burden on the teachers.
5. Schools should encourage Project-Based-Blended tasks by assigning students with STEAM projects using digital tools to reduce over-reliance on teacher-directed assignments.

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