



Socio-Digital Inequality and Student Engagement in Hybrid Learning Environments: Evidence from Colleges of Education in Zamfara State, Nigeria

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Abstract

Background: This study explores the impact of socio-digital inequality on student engagement within the hybrid learning model at Colleges of Education in Zamfara state, Nigeria.

Methods: The study adopted a correlational-predictive research design. The population was 12,361 students of NCE from Federal College of Education (Technical), Gusau and Zamfara State College of Education, Maru. A multistage sampling technique was used to select 388 students and 376 valid responses were analysed. The Socio-Digital Inequality and Student Engagement in Hybrid Learning Questionnaire was used to gather the data. Descriptive statistics, Pearson Product Moment Correlation and Multiple Regression Analysis were used for data analysis.

Results: The results indicated a significant socio-digital inequality among students, highlighting digital skills, access barriers, and usage barriers as key challenges, with digital affordability being the most critical. Student engagement in hybrid learning was moderate, showing significant negative correlations with digital inequality dimensions. Regression analysis identified socio-digital inequality as a major predictor of student engagement, explaining 40% of the variance, particularly influenced by digital affordability and digital skills.

Conclusion: Based on the study findings, it is concluded that the successful implementation of the hybrid learning model in the Colleges of Education in Nigeria is not a mere technological affair but rather, it involves an equitable digital ecosystem that considers the affordability of technology, digital competence, connectivity, and institutional support. The findings underscore the importance of more complete approaches for digital inclusion:

Keywords: Digital inequality; digital divide; hybrid learning; student engagement; higher education.



Introduction

The use of digital technologies in education has emerged as one of the most striking changes of modern higher education systems. Universities and colleges around the world are slowly incorporating technology-enabled instructional methods to enhance access, flexibility and continuity of learning (Aithal & Aithal, 2024; Wong, 2024). One such method that has gained considerable traction is hybrid learning, which integrates traditional classroom settings with digital platforms, online materials, and virtual communication. This has emerged as a valuable method, offering opportunities for personalised learning, access to a wider range of learning materials and flexibility for learners who have a range of learning needs (Martin et al., 2020; Bozkurt et al., 2022). But the idea that digital learning will automatically lead to educational inclusion has been gainsaid by the growing evidence of unequal educational experience of students in technology-supported learning. Rather, social, technological, digital, and economic conditions and disparities shape who gains the most from hybrid learning opportunities.

The problem of socio-digital inequality is the unequal capacity of both being able to participate and benefit from digital learning environments. Socio-digital inequality is the inequality in access, use and educational benefit from digital technologies for people and social groups on a systematic basis. Recent research on digital inequality has gone beyond the mere concept of access to computers and Internet, to include various other factors. Recent views focus on several aspects such as having digital devices available, accessibility of digital devices and connectivity, digital literacy, quality of technology use and the capacity to translate digital participation into educational value (van Deursen & van Dijk, 2019; van Dijk, 2020; Ragnedda, 2021). Thus, equal access to learning is not guaranteed if digital infrastructure exists in schools, as students have varying technological advantages as they enter into the learning environment.

The importance of socio-digital inequality can be explained by Digital Divide Theory and Digital Inequality Theory: Digital Divide Theory highlights the unequal access, skills, usage, and outcomes of technology that affect individuals; Digital Inequality Theory recognizes that digital inequalities affect the experience of technology. In these viewpoints, there are multiple levels of technological disadvantage. Some students might not have access to technology and/or internet services, and some students may have technology but not know how to effectively use it for academic purposes. When access and skills are present, there can be variations in the educational value that students gain from digital participation due to a range of factors, including differences in learning environments, socioeconomic support and opportunities for the meaningful use of technology (Hargittai, 2022; Robinson et al., 2020). As a result, socio-digital inequality is a technological issue as well as an educational equity matter.

In hybrid learning contexts, these inequalities have direct consequences on student engagement. Student engagement is characterized by students' active involvement, emotional connection and cognitive investment in educational activities (Fredricks et al., 2019). Engagement is not only about attending lessons online, it consists of accessing online learning materials, engaging in online discussions, communicating with instructors and peers, completing online assessments and building independent learning behaviors in a technology-supported learning environment. For students with digital disadvantages, however, technology may make it difficult to engage regularly due to the technological disadvantage. For instance, students who are not able to access shared devices or who do not have access to internet regularly or have limited digital competencies may



feel less well equipped to participate effectively in hybrid environments. However, while hybrid learning is intended to increase education opportunities, unequal conditions of digital access may inadvertently perpetuate educational inequities.

In recent years, the correlation between digital inequality and student engagement has grown more relevant in the process of designing educational systems, especially in African nations where digital transformation is happening hand-in-hand with ongoing infrastructural and socioeconomic issues. Previous studies in African universities reveal that access to the internet, internet connectivity fees, lack of electricity and digital readiness remain a challenge to students' experiences of online and blended learning (Mtebe & Raisamo, 2020; Czerniewicz et al., 2021). The COVID-19 pandemic further highlighted these disparities as institutions rapidly shifted to online and hybrid delivery models. The students who prepared digitally adapted well, while many of the disadvantaged learners faced challenges in learning resources accessibility and continued in their learning process (Adedoyin & Soykan, 2020; Bond et al., 2021).

Digital learning initiatives have been rolled out in Nigeria, and opportunities exist to enhance educational delivery, but there are large inequalities. The use of learning management systems, online communication platforms and digital instructional resources have increased in Nigerian higher education institutions. However, the experiences of students with these technologies is very different, depending on their socio-economic status, institutional support, access to the internet, network availability and digital literacy. There have been studies that have reported that many Nigerian students continue to face problems accessing technology, using technology competently and being ready to learn online, which is limiting the effectiveness of technology-integrated teaching and learning approaches (for example, Okoye et al., 2021; Afolabi et al., 2021). These challenges present several questions regarding access to learning in both settings and how hybrid learning environments add to or create new patterns of exclusion among digitally disadvantaged learners.

This is especially significant in Colleges of Education as they teach future teachers, who would affect the integration of technology in schools. Learning about digital learning environments should be a meaningful experience for teacher education students if they are to acquire the technological skills necessary for modern teaching practices. When students are taught during their student-teaching to have different digital opportunities than their peers, however, it could impact how confident they feel in their ability to confidently bring digital technologies into their future classrooms. Hence, the study of socio-digital inequality among the students of Colleges of Education has implications other than just the academic engagement of the students; it is also related to the readiness of Nigeria's education workforce for the future.

This study is important because of the educational environment in Zamfara State where issues of infrastructure development, socio-economic conditions, and access to digital environments are pertinent considerations. There has been a growing adoption of technology-supported learning approaches in colleges of Education in the State; however, differences in students' access to digital learning materials, availability of internet connectivity and digital skills may have a negative impact on their capacity to engage effectively in hybrid settings. This context is important, but the empirical research on the socio-digital inequalities that influence students' engagement in the Colleges of Education in Zamfara State is limited.



Previous research indicates there are a number of critical gaps. First, the vast majority of literature on educational digital inequality has focused on access, rather than investigating the wider aspects of digital skills, pattern of use, and educational outcomes. Secondly, the teacher education context, including Colleges of Education, is an under-researched area of Nigeria in comparison to universities. Thirdly, there is limited research that focuses on the connection between socio-digital inequality and various aspects of student engagement, such as behavioural, emotional and cognitive engagement in hybrid learning environments.

Filling such gaps is key to making hybrid learning an inclusive learning environment instead of perpetuating inequalities already in place. The study therefore involved the study of “Socio-Digital Inequality and Student Engagement in Hybrid Learning Environments: Evidence from Colleges of Education in Zamfara State, Nigeria.” The study enriches existing knowledge by expanding the discourse on digital inequality beyond access, offering insights from an under-researched teacher education context and insights that can inform policy interventions to address digital equity, institutional readiness and inclusive hybrid learning in Nigerian higher education.

Aim and Objectives

The aim of this study is to examine the influence of socio-digital inequality on student engagement in hybrid learning environments among students of Colleges of Education in Zamfara State, Nigeria. Specifically, the objectives of this study are to:

- i. Determine the dimensions and level of socio-digital inequality among students of Colleges of Education in Zamfara State, Nigeria.
- ii. Assess the level of student engagement in hybrid learning environments by examining behavioural, emotional, and cognitive engagement among students of Colleges of Education in Zamfara State, Nigeria.
- iii. Examine the relationship between socio-digital inequality and student engagement in hybrid learning environments among students of Colleges of Education in Zamfara State, Nigeria.
- iv. Determine the predictive influence of socio-digital inequality dimensions (digital access, digital skills, digital affordability, and digital usage) on student engagement in hybrid learning environments among students of Colleges of Education in Zamfara State, Nigeria.

Research Questions

The study will be guided by the following research questions:

RQ1: What are the dimensions and level of socio-digital inequality among students of Colleges of Education in Zamfara State, Nigeria?

RQ2: What is the level of student engagement in hybrid learning environments in terms of behavioural, emotional, and cognitive engagement among students of Colleges of Education in Zamfara State, Nigeria?

RQ3: What relationship exists between socio-digital inequality and student engagement in hybrid learning environments among students of Colleges of Education in Zamfara State, Nigeria?



RQ4: To what extent do digital access, digital skills, digital affordability, and digital usage predict student engagement in hybrid learning environments among students of Colleges of Education in Zamfara State, Nigeria?

Theoretical Framework: Digital Divide Theory

The study draws its inspiration from the Digital Divide Theory as it offers a robust framework for exploring how unequal access, skills and opportunities to digital technologies affect students' participation and engagement in hybrid learning environments. The theory was developed in early discussions of the inequalities between people and groups with access to information and communication technologies (ICTs) and those who do not have access. However, current understandings of the theory have gone beyond simple access to digital technologies, and encompass inequities in digital skills, in digital technology use, and in the ways in which digital technologies can benefit the user (van Dijk, 2020; Ragnedda, 2021). Recent research also continues to indicate that digital inequality is a critical issue in education as the ability to use technology positively or negatively affects how students engage in technology supported learning (Wang et al., 2024).

This study is closely connected to the Digital Divide Theory as part of the IWBIM, students are expected to have access to digital tools, but also knowledge and skills to interact with them effectively as well as digital resources. It is a theory that recognizes various strata of digital inequality. The first level is access inequality for digital access, that is, differences in the distribution of devices, internet connection and technological infrastructure. Students who do not have a dependable digital device and/or an affordable Internet connection could find it challenging to access digital learning resources and virtual activities. The second level relates to digital skills inequality, that is differences in the students' capacity to use digital technologies effectively for learning purposes. Having a device does not necessarily mean students have the skills needed to engage with learning platforms and search, or communicate effectively online (van Deursen & van Dijk, 2019).

The third dimension of theory focuses on usage and outcomes inequalities, since people might be using the same technology but gain different results as a result of their socioeconomic position, their learning environments and their digital skills (Ragnedda, 2021). This is a key reason why some students may feel a greater sense of engagement in their education through digital means within a hybrid learning system, while others are still left out despite institutional efforts to offer online opportunities. New evidence has also shown that digital inequality has been a factor in maintaining educational inequality, as students with a lack of technological resources and digital skills may find themselves facing challenges to academic engagement and success (Fang et al., 2025).

Toward this aspect of the study, Digital Divide Theory can be used as a framework to explain the impact of socio-digital inequality on student engagement in hybrid learning environments. The theory proposes that various inequities in the access to digital, digital skills, affordability, and technology usage may impact behavioral, emotional, and cognitive engagement by students. For example, students with limited access to the internet or those who do not have access to internet data services may not engage in online interaction as often, experience late assignments, or have lower motivation to engage in hybrid learning activities. Likewise, students with poor digital



competencies can have problems functioning within online environment, which decreases their confidence and mental participation in learning activities. The theory suggests that the engagement of students in the hybrid learning is not only dependent on the existence of the institutional digital platforms, but also on the social and technological environment in which students are engaged. The use of Digital Divide Theory allows this study to analyze socio-digital inequality as a multi-dimensionality and evaluate the different dimensions of digital disadvantage and its impact on students' engagement in Colleges of Education in Zamfara State, Nigeria. The theoretical lens used in the study addresses the ongoing discussion about digital equity in higher education beyond the question of "digital access" to technology to focus on the question of "digital resources and capabilities" that students must have to benefit from hybrid learning environments.

Methodology

Research Design

The study used correlational-predictive research design to investigate the relationship between socio-digital inequality and student engagement in hybrid learning model among students of colleges of education in Zamfara state of Nigeria. It is appropriate since the study looked at the natural variation of students' digital conditions and their association with engagement outcomes, rather than manipulating the study variables. The correlational part helped the researcher in answering how is the socio-digital inequality related to students' engagement and the predictive part helped the researcher in answering how much variation in students' behavioural, emotional and cognitive engagement in hybrid learning environments is explained by the dimensions of the sociodigital inequalities. The independent variable of the study was socio-digital inequality which was quantified through four dimensions viz. digital access inequality, digital skills inequality, digital affordability inequality, and digital usage inequality. Student engagement in hybrid learning environment was the dependent variable, operationalized by four dimensions of engagement, namely behavioural, emotional, cognitive and physical.

Study Area

The study was carried out in two Colleges of Education in the Zamfara State, Nigeria namely Federal College of Education (Technical), Gusau and Zamfara State College of Education, Maru. Federal College of education (Technical) Gusau is a Federal teacher education institution that is tasked with training professionally qualified teachers through the National Certificate in Education (NCE) programmes. The institution conducts teacher training in different subjects and has introduced the use of digital technologies and technology-supported teaching practices in the learning process. Zamfara State College of Education, Maru is a teacher education institution owned by the government of the state of zamfara to train teachers via the teacher education programmes called NCE. It caters to students from a variety of socioeconomic backgrounds, allowing the examination of the impact of socioeconomic and technological difference on engagement in hybrid learning. These institutions were chosen based on their significance to Teacher Education, their representation of Federal, State ownership structures and their suitability for the study of digital inequality in Nigerian Colleges of Education.



Population of the Study

The population of the study consisted of all the NCE I, NCE II and NCE III students in the two selected Colleges of Education. The total population was 12,361 students with the following percentage representation: Respondents from each stratum. The distribution of the samples was as shown in Table 1.

Table 1: Population of the Study

Institutions	Population
Federal College of Education (Technical), Gusau	5,527
Zamfara State College of Education, Maru	6,834
Total	12,361

The focus was on NCE students which was justified, as the experiences with digital learning environments of these students may shape their future competence in integrating digital learning environments into their classroom practice as teachers.

Sample Size Determination

A sample size was calculated using Taro Yamane (1967) formula:

$$[n = \frac{N}{1 + N(e)^2}]$$

Where:

n = sample size

N = population size (12,361)

e = level of precision (0.05)

$$[n = \frac{12,361}{1 + 12,361(0.05)^2}]$$

$$[n = \frac{12,361}{31.9025}]$$

[n=387.46]. Hence, the sample size was rounded off to 388 respondents.

Sampling Procedure

A multistage stratified sampling technique was used. The two Colleges of Education were purposively selected as the first stage because they are Federal and State teacher education institutions in Zamfara State. The second stage involved proportional allocation to the institutions based on their population size. The third group of students was stratified based on their NCE levels (I, II, and III) to ensure representation of students who have varying degrees of exposure to hybrid learning environments. Simple random sampling was done for respondents of each stratum at the final stage. The distribution of the samples was presented thus:

Table 2: Sample of the Study

Institutions	Population	Sample
Federal College of Education (Technical), Gusau	5,527	173
Zamfara State College of Education, Maru	6,834	215
Total	12,361	388



Instrument for Data Collection

A socio-digital inequality and student engagement in hybrid learning questionnaire (SDI-SEHLQ) was used to collect data. The instrument was based on a conceptual framework and theory of Digital Divide Theory and Digital Inequality Theory. The questionnaire consisted of three sections. Section A - Demographic Information. This section gathered information on: gender, age, institution, academic level, ownership of digital devices, previous experience of using digital learning.

Section B: Socio-Digital Inequality Scale

The scale items assessed were: Digital Access Inequality, Digital Devices, Internet Connectivity and Digital Infrastructure.

Digital Skills Inequality: digital literacy; ability to use learning platforms; confidence in the use of technology.

The Internet of Things (IOT): Financial capacity to participate in the internet; affordability of data.

Digital Usage Inequality: Use of technology in a meaningful academic way; use of digital learning resources.

Section C: Student Engagement Scale

Students' engagement was assessed by the following:

Behavioural Engagement: participation; attendance; completion of digital learning activities.

Emotional Engagement: motivation; interest; sense of belonging.

Cognitive Engagement: deep learning, self-regulation, intellectual effort. The responses were scored on a five-point Likert scale (1 = Strongly Disagree; 2 = Disagree; 3 = Undecided; 4 = Agree; 5 = Strongly Agree).

Validity of the Instrument

It was face and content validated by the experts in the fields of Educational Technology, Measurement and Evaluation, and Educational Foundations. The experts evaluated the completeness, readability, relevance to the research goals and congruence with the conceptual framework. The suggestions from the validators were included prior to final administration.

Pilot Testing and Reliability

A pilot study was undertaken with 30 NCE students from another College of Education outwith the selected institutions but with similar characteristics to the students in the selected institutions. The pilot test evaluated the items' clarity and internal consistency reliability was checked by Cronbach's Alpha coefficient.

Data Collection Procedure

After approval by the appropriate institutional authorities, the researcher gave the questionnaire to the selected respondents. Respondents were briefed on the purpose of the study, confidentiality procedures and their right to participate in the study voluntarily. Completed questionnaires were kept by the researcher and were not to include personally identified information. Completed questionnaires were retrieved after administration and screened, coded and ready for statistical analysis.



Data Analysis

Data analysis included descriptive and inferential statistics. To answer research questions about socio-digital inequality and student engagement, descriptive statistics were used such as frequency, percentage, mean and standard deviation. Pearson Product Moment Correlation was used to determine the relationship between socio-digital inequality and student engagement. Multiple Regression Analysis was carried out to see how digital access, digital skills, digital affordability and digital usage predicted student engagement. Independent sample t-test and Analysis of Variance (ANOVA) were used to examine differences based on demographic characteristics. Diagnostic tests were performed before regression analysis as to the following: normality, linearity, independence of errors, multicollinearity and homoscedasticity. All the hypotheses were tested at 0.05 level of significance.

Ethical Considerations

Ethical guidelines of educational research were followed in the study. Prior to data collection, ethical approval was given from the relevant institutional body. Respondents were asked for their informed consent, and there was voluntary participation in the study. Each participant was told that he or she could leave the study at any time for any reason without losing any benefits. Confidentiality and anonymity were achieved throughout the research procedures and data collected was solely for research and academic purposes.

Results

Preliminary Analysis and Response Rate as well as Measurement Reliability. 388 questionnaires were handed to the students of NCE, Federal College of Education (Technical), Gusau and Zamfara State College of Education, Maru. A total of 376 questionnaires were completed and were deemed as complete and valid for analysis, giving a response rate of 96.9% of the questionnaires sent. The reliability of the study constructs was checked in Cronbach's Alpha coefficient before the principal analysis. The findings showed that there was good internal consistency within all dimensions of socio-digital inequality and student engagement.

Table 3: Reliability Coefficients of Study Constructs

Construct	Number of Items	Cronbach's Alpha
Digital Access Inequality	6	0.82
Digital Skills Inequality	7	0.86
Digital Affordability Inequality	5	0.79
Digital Usage Inequality	6	0.84
Behavioural Engagement	6	0.83
Emotional Engagement	5	0.81
Cognitive Engagement	6	0.85
Overall Instrument	41	0.88



The acceptable internal consistency of measurement scales (coefficients > 0.70) was found with all coefficients. Diagnostic tests were carried out first before performing regression analysis. The results showed that the assumptions of normality, linearity, independence of errors, homoscedasticity and multicollinearity were fulfilled. The variance inflation factor (VIF) values were in the range of 1.42 to 2.18, which is not considered as a serious multicollinearity issue for the predictor variables.

Respondents' Characteristics

Table 4: Demographic Characteristics of Respondents (N=376)

Variable	Category	Frequency	Percentage (%)
Institution	FCET Gusau	168	44.7
Institution	ZSCOE Maru	208	55.3
Gender	Male	214	56.9
Gender	Female	162	43.1
Academic Level	NCE I	132	35.1
Academic Level	NCE II	126	33.5
Academic Level	NCE III	118	31.4

The respondents were adequately distributed across the two institutions and academic levels. The representation of students from both institutions provided sufficient basis for examining socio-digital inequality within Colleges of Education in Zamfara State.

Digital Access Profile of Respondents

Table 5: Digital Access Characteristics of Respondents

Indicator	Frequency	Percentage (%)
Owens smartphone	326	86.7
Owens laptop/computer	131	34.8
Has regular internet access	196	52.1
Experiences internet connectivity challenges	295	78.5
Can consistently afford internet data	155	41.2

The findings indicate that although smartphone ownership was high among students (86.7%), access to laptops and computers remained limited (34.8%). Furthermore, a large proportion of respondents experienced internet connectivity challenges (78.5%), while less than half could consistently afford internet data (41.2%). This suggests that digital inequality extends beyond device ownership to include affordability, reliability, and quality of access.



Level of Socio-Digital Inequality

Research Question One: What is the level of socio-digital inequality among students of Colleges of Education in Zamfara State?

Table 6: Socio-Digital Inequality Dimensions

Dimension	Mean	SD	Interpretation
Digital Access Inequality	3.74	0.91	High
Digital Skills Inequality	3.62	0.88	High
Digital Affordability Inequality	3.81	0.94	High
Digital Usage Inequality	3.55	0.86	High
Overall Socio-Digital Inequality	3.68	0.90	High

The results revealed a high level of socio-digital inequality among students ($M = 3.68$, $SD = 0.90$). Digital affordability inequality recorded the highest mean score ($M = 3.81$), indicating that financial constraints associated with internet access and digital services represented the most prominent barrier affecting students' participation in hybrid learning.

Level of Student Engagement in Hybrid Learning

Research Question Two: What is the level of student engagement in hybrid learning environments among students of Colleges of Education in Zamfara State?

Table 7: Student Engagement Dimensions

Dimension	Mean	SD	Interpretation
Behavioural Engagement	3.42	0.83	Moderate
Emotional Engagement	3.36	0.79	Moderate
Cognitive Engagement	3.51	0.81	High
Overall Student Engagement	3.43	0.81	Moderate

The findings indicate a moderate level of student engagement in hybrid learning environments ($M = 3.43$, $SD = 0.81$). Cognitive engagement recorded the highest mean score, suggesting that students demonstrated personal effort and commitment toward learning activities despite digital challenges.



Relationship Between Socio-Digital Inequality and Student Engagement

Research Question Three: What relationship exists between socio-digital inequality and student engagement?

Table 8: Correlation Matrix of Study Variables

Variables	Access	Skills	Affordability	Usage	Engagement
Digital Access Inequality	1				
Digital Skills Inequality	.48**	1			
Digital Affordability Inequality	.52**	.46**	1		
Digital Usage Inequality	.41**	.55**	.44**	1	
Student Engagement	-.43**	-.51**	-.54**	-.39**	1

The correlation analysis showed significant negative relationships between socio-digital inequality dimensions and student engagement. Digital affordability inequality demonstrated the strongest relationship with engagement ($r = -.54, p < .01$), followed by digital skills inequality ($r = -.51, p < .01$). This indicates that students experiencing greater digital disadvantages reported lower levels of engagement in hybrid learning environments.

Predictive Influence of Socio-Digital Inequality on Student Engagement

Research Question Four: To what extent do socio-digital inequality dimensions predict student engagement?

Table 9: Regression Model Summary

R	R ²	Adjusted R ²	F-value	p-value
0.63	0.40	0.39	61.72	<0.001

The regression model was statistically significant, $F(4,371) = 61.72, p < .001$. The predictor variables jointly explained 40% of the variation in student engagement, indicating a meaningful explanatory contribution.

Table 10: Regression Coefficients

Predictor	β	t-value	p-value
Digital Affordability Inequality	-0.31	-6.04	<0.001
Digital Skills Inequality	-0.29	-5.72	<0.001
Digital Access Inequality	-0.21	-4.15	<0.001
Digital Usage Inequality	-0.18	-3.46	0.001

The regression results showed that all dimensions of socio-digital inequality significantly predicted student engagement. Digital affordability inequality emerged as the strongest predictor, followed by digital skills inequality. The findings suggest that financial capacity and digital



competence are important factors associated with students' ability to engage effectively in hybrid learning environments.

Hypothesis Testing Summary

Summary of Hypotheses Decisions

Table 11: Hypotheses Decisions

Hypothesis	Test	Result	Decision
H01	Pearson Correlation	$r=-0.54, p<.001$	Rejected
H02	Multiple Regression	$F(4,371)=61.72, p<.001$	Rejected
H03	Independent t-test	$t(374)=-2.01, p=.045$	Rejected
H04	ANOVA	$F(2,373)=4.87, p=.008$	Rejected

Discussion of Findings

Socio-Digital Inequality as a Barrier to Equitable Hybrid Learning Participation

The study identified a high level of socio-digital inequality among the students of Colleges of Education in Zamfara State and the most dominant dimension identified was digital affordability inequality. This discovery reinforces the idea that hybrid learning participation is a function of students' socioeconomic ability to engage in relevant digital learning activities, in addition to access to digital devices and platforms. The traditional notion of the digital divide as a problem of technology access has been extended to a new perspective that encompasses costs of access, digital competence, access quality, access patterns, and learning outcomes (van Dijk, 2020; Ragnedda, 2021). This is especially relevant in the Nigerian higher education ecosystem where students cover the costs of their internet subscription, device servicing, and other electricity options necessary for accessing the internet for digital engagement at their own cost. The discovery corroborates findings in Nigeria that cost of data, limited connectivity and weak digital infrastructure remain significant challenges to technology-based learning. Ajonbadi et al. (2023) noted that the digital divide in higher education in Nigeria is not only physical but also economic and competency-related, meaning that students' ability to access and engage in digital learning is influenced by their competency and economic status. Likewise, Alimi et al. (2024) reported that Nigerian students have become more aware of the benefits of online education, but the lack of adequate infrastructure and conditions for participating in online education is a barrier to such participation.

The result also corresponds with findings from the Nigerian hybrid learning studies conducted in recent times. The study by Ajadi (2026) revealed that university students in Nigeria are broadly aware of the flexibility and ease of implementation in using hybrid learning, however, they cited issues of inadequate internet connectivity and high data costs, poor digital literacy and challenges with electricity as the significant barriers in implementing hybrid learning effectively. The findings support the idea that digital inclusion cannot be attained through the adoption of learning management systems or online platforms but must take a socio-economic approach that considers the factors which enable students to make use of them. The finding further substantiates the second and third level digital divide views. The first level relates to whether people have devices and



connections at home, the second level is related to differences in digital skills, and the third level refers to differences in outcomes of technology use (van Deursen & van Dijk, 2021). Smartphone ownership alone cannot guarantee successful engagement in hybrid learning as students need to have enough digital literacy, affordable technological connectivity, and be able to use the technology for learning purposes. This implies that digital inequalities in Nigerian Colleges of Education is an educational equity issue that goes beyond technology access.

Student Engagement in Hybrid Learning Environments

The study showed that students' engagement in hybrid learning was moderate with the level of cognitive engagement being the highest and the level of emotional engagement being the lowest. This indicates that students continued to show intellectual engagement towards learning activities, but had problems maintaining motivation, interaction, and social connection in technology-mediated learning settings. The finding is consistent with the multidimensional concept of student engagement that conceptualizes engagement as behavioral participation, emotional involvement, and cognitive investment (Fredricks et al., 2004). Hybrid learning demands students to develop self-regulation skills as well as engage with instructors and peers and stay motivated in flexible learning contexts, not only by accessing digital resources. The findings are consistent with the emerging evidence in Nigeria. A study of blended learning in the universities of the north revealed that pedagogical structure and flexibility of learning are among the positive factors that could improve students' engagement in learning while technology-related issues might reduce these advantages (Chikaji et al., 2024). Likewise, a recent study in Nigeria suggests that learners are receptive to blended learning with reported challenges of engagement persisting in cases of low infrastructure, digital readiness, and instructional support. The moderate engagement in this study also indicates an important contradiction in the hybrid learning study, however. Although technology-based learning can enhance flexibility and autonomy, it can also re-create new types of exclusion when students don't have the means to engage with the learning. Thus, it is important to understand that the adoption of hybrid learning is not a universal solution and is contingent on the synergy of technology, institutional support, pedagogy, and students' socio-economic contexts.

Socio-Digital Inequality and Student Engagement Relationship

The results showed that there was a significant negative correlation between socio-digital inequality and student engagement. This suggests that the disadvantaged students are more likely to report low levels of behaviour, emotion and cognition engagement when learning in hybrid environments. This result is an empirical confirmation of the Digital Divide Theory, which suggests that the unequal digital environment leads to unequal educational experience. Pupils who have difficulty accessing the internet, connecting to it, using it or being competent at it will be at risk of being denied opportunities to participate, interact and to learn. This finding aligns with the findings from the Nigerian higher education studies which revealed that students' technological conditions and institutions' readiness affects digital learning outcomes. Babalola and Gbolagade (2026) noted that digital transformation in higher education in Nigeria has brought new opportunities for engagement but also highlights inequalities in terms of conditions of engagement, digital literacy and infrastructure. Likewise, research conducted in Nigerian Universities shows that technologies infrastructure and digital preparedness are still crucial factors in the learning experiences of students in online learning in Nigeria. But Digital inequality and engagement



should not be taken to be purely technological. The impact of digital inequality can be mitigated or amplified due to institutional practices, lecturer competence, learning design and student support mechanisms. This is why while some institutions struggle to get the same outcomes from hybrid learning as others, they do not necessarily have the same technological issues.

Predictive Influence of Socio-Digital Inequality on Student Engagement

The study showed that socio-digital inequality was a strong predictor of student engagement, accounting for 40% of the variance in the outcome of engagement. Digital affordability inequality and digital skills inequality were the strongest predictors. The fact that affordability is a key factor suggests that economic viability is still a crucial requirement for digital participation. Students can be mobile phone users and have access to digital platforms, but be less engaged if they do not always have access to the internet. A study in Nigeria recently identified data cost, unreliable electricity and connectivity as the critical challenges that impact the effectiveness of hybrid learning. The predictive role of digital skills also shows that lack of skills does not generate a significant educational impact. Digital literacy skills are needed for navigating online platforms, communicating effectively, assessing and evaluating information and engaging in independent technology-supported learning activities. This is in line with the recent research conducted in the Nigerian higher education that also revealed that digital competence is correlated with students' engagement and successful involvement in the online learning environment. The results of this study reveal that from the Community of Inquiry viewpoint, socio-digital inequality has a negative impact on students' experience of teaching presence, social presence, and cognitive presence (Garrison, 2021). Students who have low connectivity can interact less actively in online discussions, interact less with lecturers and students, and have less chance for the construction of knowledge.

Theoretical Contribution and Implications

The study adds to the scholarship of digital inequality by showing that, in the context of Nigerian Colleges of Education, rather than access to digital technologies, the quality and sustainability of the digital engagement of learners is a more significant factor in influencing the nature of hybrid learning engagement. This study shows that digital competence and affordability are more likely to predict outcomes of students' engagement with technology than efforts driven by the measurement of digital inclusion as simply owning a device. The findings further contribute to the discussion of the hybrid learning in the literature, by demonstrating that technology-mediated learning in developing contexts needs to be viewed and designed as a socio-technical system, in which infrastructure, economic capacity, digital competence, pedagogy, and institutional support are all involved. Improving hybrid learning for Colleges of Education means making comprehensive interventions such as low-cost student connectivity schemes, digital literacy programmes, upgrading of institutional infrastructure, developing the digital competence of lecturers, as well as developing inclusive learning designs that take into consideration learners' different socio-economic contexts.



Conclusion

The study examined socio-digital inequality and student engagement in hybrid learning environment of the students of Colleges of Education in Zamfara State, Nigeria. The findings clearly show that hybrid learning offers great possibilities for flexibility, accessibility and technology-supported learning; but not for everyone equally. Socio-digital inequality is still a big challenge, especially regarding digital affordability, connectivity, digital skills and meaningful use of technologies. The study found students' socio-digital inequality was high and socio-economic status poses as the greatest barrier to success. This suggests that there is a strong relationship between socioeconomic factors and access to digital learning opportunities. The study also showed that students' involvement in hybrid learning was moderate, indicating that students are willing to engage in learning activities with the help of technology, but they do not have the same level of engagement because of differences in digital conditions. The study also found a huge negative correlation between socio-digital inequality and student engagement. Learners who are more digitally disadvantaged reported lower levels of behavioural, emotional and cognitive engagement. Additionally, the predictive analysis showed that 'digital affordability' and 'digital skills' were the most powerful predictors of the engagement outcomes. This means that a healthy transition to hybrid learning goes beyond just having digital platforms, it also means that there needs to be availability, cost-accessibility, digital competences, welcoming institutional modalities and pedagogies.

The study joins the emerging digital inequality literature by showing that digital exclusion is not limited to the ownership of devices but is a more complex issue that encompasses the capacity of learners to meaningfully engage and leverage digital learning spaces in Nigerian Colleges of Education. Such a discovery could be especially pertinent for teacher education institutions, since that under-resourced student teacher could be entering the profession with a lack of confidence or capacity to bring technology into the classroom. Thus, hybrid education needs to be understood as a teaching equality problem that needs an integrated institutional and policy action. Hybrid learning might, if not actively combating, exacerbate socioeconomic and competency-based digital divides if insufficient measures are implemented to address them.

Recommendations

The following recommendations are made based on the results and conclusions of the study:

- i. Colleges of Education should implement structured digital inclusion programmes with an objective of enabling students to access the internet with low costs, have access to devices and have a strong internet connection while on campus. Partnerships with telecom firms to offer cost-effective educational data packages to students should be explored by institutions. These interventions would directly tackle the current problems with affordability outlined in the study.
- ii. Digital skills accounted for a significant contribution to the students' engagement, hence, compulsory digital literacy/educational technology training of NCE students should be introduced in the Colleges of Education. Such programmes are recommended to emphasize real world abilities including online learning management systems, digital research skills, collaborative digital tools, cyber security awareness and technology enhanced pedagogical skills.



- iii. Infrastructure development of digital infrastructure in Teacher Education Institutions should be a priority for relevant agencies such as the National Commission for Colleges of Education (NCCE), Federal Ministry of Education and digital development stakeholders. The investments must be directed towards affordable broadband access, sustainable electricity solutions, digital learning facilities and digital learning policies. In recent conversations on Nigeria's journey of change in digital education, it was also highlighted that infrastructure and digital literacy are still critical needs for inclusive technology-supported education.
- iv. Colleges of Education (CoE) should offer Continuous Professional Development (CPD) for lecturers in the design of inclusive hybrid learning experiences. Lecturers should be encouraged to use low bandwidth instruction, make learning resources flexible, and take into account the students' level of digital access and competence. This will sustain participation instead of adding barriers to participation in blended learning environments.

Limitations

The study has several limitations, however, despite this, it has contributed in several ways. First, the study was restricted to the two study sites out of the total four Colleges of Education in Zamfara State. While the institutions gave useful information on the socio-digital divide in teacher education, the results may not be generalizable for all teacher education institutions in Nigeria and other parts of the world with different socio-economic and technological environments. Secondly, the research design used in the study was cross sectional research that was able to examine the students' experiences at a particular time. It was therefore not possible to study changes in socio-digital inequality and students' engagement in time as institutions evolve their hybrid learning systems. Thirdly, the study was based mainly on questionnaire data that were self-reported. The instrument had a good level of reliability, but personal experience, expectations and/or memory limitations could have affected the respondents' perceptions. The study excluded objective digital usage metrics like learning management system usage reports, internet usage records, and platform engagement metrics.

Further research is recommended to examine socio-digital inequality and hybrid learning engagement across Nigeria's geopolitical zones, comparative studies should be carried out. These studies would offer a more comprehensive national level of evidence on issues of digital inclusion. Research should examine the changing digital access, skills, and engagement of students over time in the context of growing institutions' hybrid learning systems and digital infrastructure. Further, the mixed methods studies should integrate quantitative surveys with interviews, focus groups, classroom observations, and digital learning analytics to better understand students' lived experiences of digital inequality and its impact on digital learning participation. Furthermore, the development of hybrid learning outcomes should be explored through the lens of digital competence of lecturers, institutional readiness, and implementation of policies as future research. This would provide a more holistic understanding of the interplay between institutional factors and digital inequalities at the student level.



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