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An Appraisal of the Correlation between Cloud Computing Adoption and Science Teachers' Effectiveness in Nigerian Secondary Schools

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ABSTRACT

Over the years, education managers all over the world have been interested in investigating the relationship between the use of technology and its impact on teaching and learning. This study explores the relationship between cloud resource usage and teacher effectiveness among secondary school science teachers in Cross River state of Nigeria. The objectives include examining the extent of cloud resource usage, evaluating teachers' perceived effectiveness and identifying any correlation among these factors within the Calabar Education Zone. Using a quantitative, survey-based approach, data was collected from 150 teachers to measure the sample's variable through a structured questionnaire and analyzed using frequency tables, mean standard deviation and Pearson's correlation coefficient. The study found that there was moderate cloud resource usage and a strong correlation between cloud resource usage and teacher effectiveness. It was recommended that teachers should be adequately trained, and government should enhance the availability of cloud resources.

Keywords: Cloud Computing; Nigeria; Secondary Schools; Science Education; Teacher Effectiveness

Background

The technological age of the 21st century has transformed global activities, making tasks faster, cheaper, and widely accessible (Kara & Yildiz, 2022). Technology serves diverse users, enabling business, communication, and effective time management (Baharuddin et al., 2021). Its influence is especially notable in education, where it plays a crucial role in enhancing learning processes (Raja & Nagasubramani, 2018) In the 21st century, cloud computing has become integral to enhancing teaching and learning, especially post-COVID-19. Defined as delivering computing services via the internet, cloud computing offers cost-effective, scalable resources that support collaboration among educators and students (Atakpa et al., 2023). It provides essential tools and infrastructure, allowing for flexible access to applications, storage, and computing power as needed (Helaimia, 2023).

Integrating technology into science education is crucial, particularly as today's youth are heavily reliant on it (Yildiz & Celik, 2020). Science education drives innovation and technological advancement (Osborne & Dillon, 2008), but in developing nations like Nigeria, challenges such as poor infrastructure, inadequate resources, and a shortage of qualified teachers hinder its effectiveness (Ogunmade, 2005). Cloud computing offers a potential solution by providing diverse learning resources, promoting innovative teaching methods, and improving classroom management (Alshwaier, Youssef, & Emam, 2012). However, research on the impact of cloud computing on teacher effectiveness in Nigerian schools is limited, with most studies focusing on developed countries (Akin, Matthew, & Comfort, 2014).

While previous studies (Gloria & Oluwadara, 2016; Olokoba et al., 2014) have explored technology's impact on education in Nigeria, little research focuses on cloud resources and science teachers' effectiveness. This study aims to fill that gap by examining the correlation between cloud resource usage and science teachers' effectiveness in secondary schools within the Calabar Educational Zone, Cross River State. The research is significant as it provides insights for shaping educational policies and practices, offering recommendations for policymakers, administrators, and teachers, while contributing to the literature on educational technology in developing nations.

The study was guided by the following research objectives:

To determine the extent of use of cloud resources among science teachers in secondary schools in Calabar Municipal Educational Zone.

To assess the perceived effectiveness of science teachers in secondary schools within the Calabar Municipal Educational Zone.

To establish the correlation between cloud computing adoption and the effectiveness of science teachers in secondary schools within the Calabar Municipal Educational Zone.

Research Questions are as follows:

What is the extent of use of cloud resources among science teachers in secondary schools in Calabar Municipal Educational Zone?

What is the perceived level of effectiveness of science teachers in secondary schools within the Calabar Municipal Educational Zone?

What is the correlation between cloud computing adoption and the effectiveness of science teachers in secondary schools within the Calabar Municipal Educational Zone?

Literature Review

Cloud Computing

The most recent area of technology deployed to make teaching and learning seamless and effective, especially in this post-COVID-19 era, is cloud computing. Cloud computing is a form of technology that enables computer resources, from computing power to computing infrastructure, applications, business processes, and personal collaboration, to be delivered to you as a service wherever and whenever you need it. Cloud computing is also a computing model in which various resources, including computing power, storage media, network connectivity, and software applications, are provided as services through network channels. These resources can be accessed from anywhere, as long as there is an internet connection, and the devices are physically located in appropriate locations. It is worth noting that the establishment of a simple cloud computing network can even be achieved within a local network or intranet environment (Maimunah, & Yakti, 2012).

Cloud Computing in Education

Cloud computing has emerged as a transformative technology in various sectors, including education. The most recognised definition was provided by the National Institute of Standards and Technology (NIST), where cloud computing is defined as ‘a model for enabling convenient on-demand network access to shared configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and dynamically released with minimal management effort or service provider intervention’ Mell, (2011).

As for the benefits of cloud computing in the context of education, there are several of them: cost-effectiveness, scalability, and availability of resources for students (Sultan, 2010). Ercan (2010) stated that by using cloud computing in education, students and teachers can work together effectively, share educational content, and act as flexible learning solutions. These benefits are important for developing countries such as Nigeria because educational institutions in these contexts are usually operating under constrained resources (Eze, Chinedu-Eze, & Bello, 2018).

A few previous works have investigated cloud computing adaptation within the learning environment. For example, Akande, & Van Belle, (2013) examined the barriers to cloud computing adoption in the higher education institutions in South Africa. They found out that technological and organisational attributes like relative advantage and top management support have an impact on the adoption of the technology. In the same vein, Akin, Matthew, & Comfort, (2019) investigated the determinants of cloud computing adoption in Nigerian universities; the study found that perceived usefulness, perceived security risk, and perceived institutional support were the primary drivers of cloud computing adoption.

Teacher Effectiveness in Science Education

Teacher performance is a comprehensive construct that covers different dimensions of teaching practices and their effects on learners’ achievement (Scheerens & Blömeke, 2016). Several factors contribute to teacher effectiveness in science education. These include subject matter knowledge, pedagogical content knowledge, classroom management skills, and the ability to use diverse instructional strategies (Shulman, 1986; van Driel, Berry, & Meirink, 2014). Additionally, access to educational resources and professional development opportunities have been identified as critical factors in enhancing teacher effectiveness (Darling-Hammond, 2017).

Cloud Resources and Teacher Effectiveness

The potential impact of cloud resources on teacher effectiveness has gained attention in recent years. Consequently, several attempts have been made to unearth the relationship between the utilisation of cloud computing and teacher effectiveness (Debes, 2021).

Alshwaier, Youssef, & Emam, (2012) argued that cloud computing could enhance teacher effectiveness by providing access to a wide range of digital resources, facilitating collaboration among educators, and enabling more efficient classroom management. This efficiency means more time spent on lesson planning, individualised instruction, and creating a welcoming environment for students. For example, a study about the impact of using cloud-based applications by Gupta, et al., (2021) in schools has demonstrated a positive connection between teachers' integration of cloud-based applications and student engagement. Teacher readiness is a crucial part of this process. The research conducted in Jordan revealed that although cloud-based tools were full of advantages, teachers with low levels of computer literacy had difficulties integrating them into their teaching. Furthermore, the widespread distribution of the cloud technology assists in providing for the provision of the learning materials and enables an adaptable and flexible teaching/learning process in which the students can continuously revisit the topics and complete assignments after the traditional classes have ended (Ali & Alourani, 2021).

Empirical studies on the relationship between cloud computing adoption and teacher effectiveness, particularly in science education in developing countries, are limited. Most research has focused on technology's general impact on teaching practices. In Nigeria, Etim, Upula, and Ekpo (2016) found a positive relationship between cloud computing and English teachers' effectiveness, noting that teachers perform better when using cloud resources. However, some teachers had not fully adopted cloud technology. Similar findings were reported in Akwa Ibom State, where university lecturers were underperforming due to incomplete adoption of cloud technology. While these studies address tertiary education, secondary school teachers in Nigeria, particularly in Cross River State, have been overlooked. The current study aims to fill this gap by examining the correlation between cloud resource usage and science teachers' effectiveness in Nigerian secondary schools. This research contributes to understanding how cloud computing can enhance teaching practices and educational outcomes, particularly in science education in developing countries like Nigeria.

Methods

This study utilized a quantitative correlational survey to examine the link between cloud resource use and secondary science teacher effectiveness in Calabar Educational Zone, Cross River State. Grounded in Davis's (1989) Technology Acceptance Model (TAM), the framework posits that perceived usefulness and ease of use drive technology adoption. The study targeted all 272 science teachers in public secondary schools within Calabar Educational Zone, Cross River State, Nigeria (Cross River State Ministry of Education, 2023). A sample of 150 teachers was selected through stratified random sampling, ensuring proportional representation by subject (Biology, Chemistry, and Physics), sample size table for 95% confidence and 5% margin of error.

Data was collected using a structured questionnaire titled “Cloud Computing Adoption and Science Teacher Effectiveness Questionnaire” (CCASTEQ). The questionnaire consisted of three sections:

Section A: Demographic information (e.g., age, gender, teaching experience, subject taught)

Section B: Cloud Computing Adoption Scale (CCAS)

Section C: Science Teacher Effectiveness Scale (STES)

Both the CCAS and STES used a 5-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree). Each scale comprised 30 items related to each of the research questions.

To ensure content validity, two professors in Science Education and Educational Technology at the University of Calabar reviewed the instrument. A pilot study with 30 teachers in Ogoja Educational Zone was conducted for reliability, using Cronbach's alpha. The reliability coefficients were 0.04 for the CCAS and 0.91 for the STES, indicating high reliability of the scales.

Over two weeks, questionnaires were administered in selected schools by the researcher and two trained assistants. Approval was secured from educational authorities and school principals, with participant consent and confidentiality assured.

The 26th version of the Statistical Package for Social Sciences (SPSS) was used to analyse the collected information. The degree of cloud resource use and perceived teacher effectiveness were studied using descriptive statistics (mean, standard deviation, frequency, and percentage). The coefficients of correlation between use of cloud resources and science teacher effectiveness were analysed by Pearson's product-moment coefficient of correlation. The significance level was set at 0.05.

Results and Discussion

Demographic Characteristics of Respondents

Out of the 150 questionnaires distributed, 142 were properly filled out and returned, representing a response rate of 94.7%. Table 1 presents the demographic characteristics of the respondents.

Table 1: Demographic Profile of Respondents

Characteristic	Category	Frequency	Percentage
Gender	Male	78	54.9%
	Female	64	45.1%
Age	20-30 years	28	19.7%
	31-40 years	53	37.3%
	41-50 years	42	29.6%
	Above 50 years	19	13.4%
Teaching Experience	1-5 years	31	21.8%
	6-10 years	47	33.1%
	11-15 years	38	26.8%
	Above 15 years	26	18.3%
Subject Taught	Biology	52	36.6%
	Chemistry	46	32.4%
	Physics	44	31.0%

The demographic data shows that in terms of gender, most of the respondents are male represented by 54.9%, while females were represented by 45.1%. In terms of age, most of the sampled respondents, 37.3% and 29.6%, are aged between 37.3% and 29.6%, respectively. Regarding teaching experience, the majority of the sampled respondents, 33.1% and 26.8%, had teaching experience of 6-10 years and 11-15 years, respectively. In terms of the subject taught, most of the respondents, represented by 36.6% of the sampled population, taught Biology.

Overall, the demographic data shows a relatively balanced distribution of respondents across the characteristics considered. This indicates a diversity in the sample. Such diversity enhances the representativeness of the study.

Research Question 1: Level of Cloud Computing Adoption

To address the first research question, descriptive statistics were calculated for the Use of Cloud Resources Scale (UCRS). Table 2 presents the mean scores and standard deviations for each item, as well as the overall scale.

Table 2: Descriptive Statistics for Use of Cloud Resources Scale (N = 142)

Item	Statement	Mean	SD
1.	Familiarity with cloud computing	3.45	1.12
2.	Use of cloud storage services	3.62	1.08
3.	Collaboration with cloud-based tools	3.21	1.15
4.	Accessing online educational resources	3.78	0.98
5.	Use of cloud-based learning management systems	2.89	1.22
6.	Incorporation of cloud-based applications in teaching	3.15	1.18
7.	Use of cloud computing for assessment and grading	2.76	1.25
8.	Participation in cloud computing professional development	2.54	1.31
9.	Encouraged students to use cloud-based tools	3.32	1.14
10.	School administration support for cloud computing	3.05	1.20
11.	Confidence in using cloud computing tools	3.18	1.16
12.	Regular updating of teaching materials using cloud applications	3.09	1.19
13.	Use of cloud computing for communication	3.41	1.10
14.	Integration of cloud-based simulations	2.87	1.24
15.	Use of cloud-based data analysis tools	2.68	1.28
16.	Collaboration with teachers from other schools	2.95	1.21
17.	Use of cloud computing for personalised learning	3.02	1.20
18.	Improved productivity due to cloud computing	3.38	1.13
19.	Believe that cloud computing enhances science education	3.56	1.06
20.	Willingness to learn new cloud-based technologies	3.72	1.01
21.	Accessing scientific journals through cloud platforms	3.24	1.15
22.	Use of cloud-based presentation tools	3.48	1.09
23.	Use of cloud computing for backup and recovery	3.35	1.12
24.	Participation in online professional learning communities	2.98	1.22
25.	Design and sharing of multimedia content	3.19	1.17
26.	Belief in improved accessibility of resources	3.65	1.04
27.	Use of cloud-based tools for analysis of student performance	3.08	1.19
28.	Incorporation of cloud-based collaborative projects	2.92	1.23
29.	Improved ability to provide timely feedback	3.29	1.14
30.	Support for the integration of cloud computing	3.11	1.18

The overall mean score for the use of cloud resources was 3.20 (SD = 0.68), indicating a moderate level of adoption among science teachers in the Calabar Municipal Educational Zone. The highest mean scores were recorded for: accessing online educational resources (M = 3.78, SD = 0.98); willingness to learn new cloud-based technologies (M = 3.72, SD = 1.01); belief in improved accessibility of resources (M = 3.65, SD = 1.04); use of cloud storage services (M = 3.62, SD = 1.08). The lowest mean scores, on the other hand, were recorded for: participation in cloud computing professional development (M = 2.54, SD = 1.31); use of cloud-based data analysis tools (M = 2.68, SD = 1.28); use of cloud computing for assessments and grading (M = 2.76, SD = 1.25); integration of cloud-based simulations (M = 2.87, SD = 1.24).

Overall, the high mean scores for some of the items suggest that teachers are open to using cloud resources and recognises the potential benefits of cloud resources, especially in accessing online educational resources, while the lower scores for some of the items suggest that there are areas where additional support and training may be needed to increase the use of cloud resources.

Research Question 2: Perceived Level of Science Teacher Effectiveness

To address the second research question, descriptive statistics were calculated for the Science Teacher Effectiveness Scale (STES). Table 3 presents the mean scores and standard deviations for each item, as well as the overall scale.

Table 3: Descriptive Statistics for Science Teacher Effectiveness Scale (N = 142)

Item	Statement	Mean	SD
1.	Effective communication of scientific concepts	4.12	0.78
2.	Use different teaching methods	3.98	0.85
3.	Encouragement of critical thinking and problem solving	4.05	0.82
4.	Creation of positive learning environments	4.18	0.76
5.	Effective classroom management	3.89	0.88
6.	Use of formative assessment strategies	3.76	0.92
7.	Provision of timely and constructive feedback	3.82	0.90
8.	Integration of real-world applications	3.98	0.84
9.	Encouraging student interest in science	4.08	0.80
10.	Effective use of demonstrations and experiments	3.91	0.87
11.	Adaptation of teaching strategies	3.85	0.89
12.	Collaboration with colleagues	3.72	0.94
13.	Staying updated with current developments	3.68	0.96
14.	Effective use of technology in instruction	3.58	1.02
15.	Promotion of scientific literacy	3.94	0.86
16.	Encouragement of student questions and ideas	4.15	0.77
17.	Guidance in scientific investigations	3.87	0.88
18.	Developing a deep understanding of core concepts	3.92	0.86
19.	Integration of interdisciplinary connections	3.65	0.98
20.	Addressing misconceptions in sciences	3.79	0.91
21.	Use of differentiated instruction	3.71	0.95
22.	Making of collaborative scientific projects	3.62	0.99
23.	Communicating the relevance of science	4.02	0.83
24.	Promotion of scientific writing and communication	3.74	0.93
25.	Data-driven decision making	3.56	1.03
26.	Integration of environmental and sustainability issues	3.81	0.90
27.	Encouragement of hypothesis development and testing	3.88	0.87
28.	Promotion of ethical implications in science	3.70	0.96
29.	Effective use of analogies and simulations	3.83	0.89
30.	Opportunities for students to present findings	3.69	0.97

The overall mean rating score of perceived science teacher effectiveness was 3.78 (SD = 0.76), which represented a reasonably high perceived effectiveness among science teachers in the Calabar Municipal Educational Zone. The highest mean scores were recorded for items: creation of a positive learning environment, with an overall mean of 4.18 (SD = 0.76) and encouragement of student questions and ideas, with an overall mean of 4.15 (SD = 0.77). The lowest mean scores were for data- driven decision making (M = 3.56, SD = 1.03) and Use of technology in instruction (M = 3.58, SD = 1.02).

Research Question 3: Relationship between Cloud Computing Adoption and Science Teacher Effectiveness

To address the third research question, a Pearson product-moment correlation analysis was conducted to examine the relationship between the use of cloud resources and science teacher effectiveness. Table 4 presents the results of this analysis.

Table 4: Correlation between Cloud Computing Adoption and Science Teacher Effectiveness (N = 142)

Variables	1	2
Cloud Computing Adoption	1	
Science Teacher Effectiveness	0.62*	< 1.001

*Correlation is significant at the 0.001 level (2-tailed).

The results show that there exists a strong positive relationship between the use of cloud resources and science teacher effectiveness ($r = 0.62$, $p < 0.001$). From this, there is an indication that as the extent of use of cloud resources increases, so does the perception of the effectiveness of science teachers.

The findings of this study provide valuable insights into the relationship between cloud computing adoption and science teacher effectiveness in Nigerian secondary schools, specifically within the Calabar Municipal Educational Zone of Cross River State. The findings are discussed based on the following three research questions that formed the research framework of the study.

Level of Cloud Computing Adoption

The results revealed a moderate level of cloud computing adoption among science teachers ($M = 3.24$, $SD = 0.89$). This finding is consistent with previous studies on technology adoption in Nigerian educational settings.

The highest mean scores for cloud computing adoption were observed in areas such as accessing online educational resources and willingness to learn new cloud-based technologies. This implies that the science teachers in the study area are receptive to embracing the use of cloud computing in teaching practices with appreciation of the benefits. This is in line with Eze, Chinedu-Eze, & Bello's (2018) study, where the Nigerian educators ascribed high utility to cloud computing to transform engineering and technology teaching and learning processes. However, the lower mean scores in areas such as participation in cloud computing professional development and use of cloud-based data analysis tools indicate potential areas for improvement. This corroborates the findings of Akin, Matthew, & Comfort, (2019), who identified the need for more comprehensive training and support systems to facilitate cloud computing adoption in Nigerian higher education institutions. The present study extends these findings to the secondary school context, highlighting similar needs at this educational level.

Perceived Level of Science Teacher Effectiveness

The majority of science teachers in Calabar Municipal Educational District are confident in their teaching abilities, especially in fostering positive learning environments and encouraging student engagement, key elements of effective science teaching (Windschitl, 2009). However, lower proficiency was found in areas like data-driven decision-making and technology use, despite some reliance on cloud computing. This suggests that, although teachers utilize cloud resources, they may not be maximizing these tools to improve instructional effectiveness, especially in data analysis and integration of technology. Gloria and Oluwadara (2016) similarly highlighted the need for focused training to enhance Nigerian science teachers' technology integration in teaching.

Relationship between Cloud Computing Adoption and Science Teacher Effectiveness

Another perceived significant relationship identified in this study is the positive correlation between the adoption of cloud computing and science teacher effectiveness ($r = 0.62$, $p < 0.001$). This result implies that the more teachers embrace cloud computing technologies and incorporate them into their teaching practice, the higher the perception of their efficiency in the teaching of science. This is an important undertone to the research works to do with use of technological products in the cause of enhancing the teaching proficiency of teachers. For example, Blau, & Shamir-Inbal, (2017) described a study that established a link between technology literacy and technology integration with the teachers' perceived self-efficacy and professional growth. The present study therefore extends these findings to the more specific context of cloud computing in Nigerian secondary schools.

It is important to point out that there is a rather high level of relationship between the adoption of cloud computing and the level of teacher performance, which can be explained by several reasons. While using cloud computing may improve the availability of resources by teachers, support their interactions with their peers, and increase efficiency of managing practices within the classrooms. These benefits are in concordance with the advantages of cloud computing in education as proposed by Alshwaier, Youssef, & Emam, (2012). Further, the introduction of cloud use may be pushing for greater student-centred learning based on the high response ratings in aspects such as encouraging student questions and promoting a positive learning ambience. This is in agreement with Eze, Chinedu-Eze, & Bello (2018), who pointed out that cloud computing enhances interactive learning and teaching in Nigerian higher education.

Conclusion

This study examined the link between cloud computing adoption and science teacher effectiveness in secondary schools within Calabar Municipal Educational District, Cross River State, Nigeria. Findings showed a moderate level of cloud computing adoption but a relatively high level of perceived teacher effectiveness, with a strong positive correlation between the two. This suggests that increased adoption of cloud technologies positively influences science teaching performance. In light of the push to advance science education and technology use in Nigeria, these insights offer valuable guidance for stakeholders in education. Key recommendations include enhancing professional development programs tailored to cloud computing integration in science teaching, improving school infrastructure to support cloud use, and developing policies that address data security, privacy, and equitable access. Additionally, fostering collaborative learning communities among teachers could promote experience-sharing on cloud applications in science education, while integrating cloud technologies into the science curriculum could further enrich the learning process. Future research is encouraged to assess cloud computing's impact on student achievement and explore adoption variations across different educational regions in Nigeria.

Declarations

Ethics Approval and Consent to Participate: Not applicable.

Conflicts of Interest: There is no conflict of interest in the author's byline.

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