The Role and Applications of Internet of Things (IoT) in higher education: Uses and ways IoT affects students' learning

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Article Info

ISSN (online): 2582-7138
Impact Factor: 5.307 (SJIF)
Volume: 05
Issue: 02
March-April 2024
Received: 01-02-2024;
Accepted: 17-02-2024
Page No: 243-249

Abstract
Internet of things involves interconnected devices and technology facilitating communication between devices and the cloud, as well as among devices themselves. The study is correlational study designed to investigate the role and applications of internet of things in higher education: Uses and ways IoT affects students' learning. The population of the study is 88 year two students in the department of education, School of Education and Humanities, Babcock University, IIishan and 65 year two students in the department of educational technology, School of computer and Information science, Crawford University, Igbesa. A sample of 100 students was used for the study. A simple random sampling technique was used for the study. The Instrument used for the study was a structured questionnaire titled the role of Internet of Things in Education: Uses and ways IoT affects student's learning (RITEUWIOTASL) with 30 items. For the study, face and content validity were used. Using Pearson product moment correlation, reliability co-efficient of 0.86 was found. The study's statistical methods included the mean and z test. The study found that IoT devices contribute to campus security, through the integration of surveillance cameras, access control systems and sensors and also IoT facilitates efficient management of educational resources including textbooks, equipment, and digital content. Based on the findings, it was recommended that Educational institutions should invest in comprehensive professional development programs for educators to enhance their understanding of IoT technologies and their effective integration into teaching practices. This will empower educators to leverage IoT tools to create innovative and engaging learning experiences.

Keywords: Internet of things, smart classroom, digital contents, remote learning, collaboration tools, learning management systems

Introduction

The Internet of Things (IoT) is a diverse field that encompasses various technologies without a singular theoretical framework, evolving over time through contributions from researchers and visionaries. It involves interconnected devices and technology facilitating communication between devices and the cloud, as well as among devices themselves (Alexander, 2023) [2]. In the realm of education, IoT can revolutionize learning by introducing smart, connected devices and systems.

Aldowah, Rehman, Ghazal, & Umar (2017) [1] assert that IoT plays a crucial role in shaping smart education, utilizing connected devices, sensors, and data analytics to enhance different aspects of the learning environment. A smart classroom integrates technology and digital tools to enrich the learning experience for both educators and students (Biju, Vamsi, & David, 2021) [4]. The term "smart classroom" encompasses various technologies and features designed to create a more interactive, engaging, and efficient learning environment. The components and characteristics often associated with smart classrooms include:

- Interactive Whiteboards: Interactive whiteboards allow educators to display and interact with digital content, annotate lessons, and engage students in a collaborative learning experience.
- Audio-Visual Systems: High-quality audio-visual systems, including projectors and sound systems, contribute to a more immersive and effective teaching and learning environment (Khan, Nisar, Sohail, & Shehzadi (2018).
- Connected Devices: Smart classrooms are equipped with devices such as tablets, laptops, and interactive displays that enable seamless communication and collaboration among students and teachers (Zubovich, 2023).
- Internet of Things (IoT) Devices: IoT devices, such as sensors and smart gadgets, can be used to collect data on classroom activities, monitor environmental conditions, and provide insights for optimizing the learning environment (Mullett, 2018).
- Learning Management Systems (LMS): Integrated digital platforms allow educators to manage course materials, assignments, and assessments, while students can access resources and collaborate online (Tarun, 2023).
- Remote Learning Capabilities: Smart classrooms often incorporate technology that supports remote or online learning, enabling students to participate in classes from different locations (Ramlowat & Pattanayak, 2019).
- Adaptive Learning Software: Educational software and applications that adapt to individual student needs, providing personalized learning experiences and feedback.
- Collaboration Tools: Smart classrooms include tools for collaborative work, such as video conferencing, real-time document sharing, and interactive group activities (Remya, 2021).
- Data Analytics: The use of data analytics tools allows educators to analyze student performance, track progress, and make informed decisions to enhance teaching strategies.

Smart classrooms leverage IoT's benefits in collecting data on classroom activities, monitoring conditions, and optimizing the learning environment (Zubovich, 2023). The significance of IoT in education is highlighted by its contributions to personalized learning, efficient teaching strategies, and an enhanced overall learning experience (Shubham, 2023).

Statement of the Problem

The rapid integration of Internet of Things (IoT) technology in the field of education has led to a significant transformation of traditional learning environments and methods. As IoT becomes increasingly prevalent in educational settings, it is crucial to gain a thorough understanding of the diverse applications and the ways in which it impacts students' learning experiences. Despite the growing use of IoT in education, there is still a gap in our knowledge about the full range of applications that IoT offers to enhance both teaching and learning. The deployment of IoT devices has the potential to revolutionize pedagogical approaches by providing personalized and adaptive learning experiences. However, there is a lack of comprehensive research examining how IoT influences teaching methods, curriculum design, and the overall educational landscape. The adoption of IoT devices in educational institutions raises significant concerns related to data security and the privacy of students.

Aim and objectives of the study

The aim of the study is to investigate the role of internet of things in education: Uses and ways IoT affects student's learning. Specifically the study intends to:

1. Examine the uses of internet of things in tertiary institutions in Ogun State, Nigeria
2. Investigate the role of internet of things in tertiary institutions in Ogun State, Nigeria
3. Describe the impact of internet of things on students in tertiary institutions in Ogun State, Nigeria
4. Identify places where internet of things can be applied in tertiary institutions in Ogun State, Nigeria
5. Examine the challenges of internet of things on students in tertiary institutions in Ogun State, Nigeria

Research Questions

1. What are the uses of the internet of things in tertiary institutions in Ogun State, Nigeria?
2. What are the roles of internet of things in tertiary institutions in Ogun State, Nigeria?
3. What is the impact of internet of things on students in tertiary institutions in Ogun State, Nigeria?
4. Are there places where internet of things can be applied in tertiary institutions in Ogun State, Nigeria?
5. What are the challenges of internet of things on students in tertiary institutions in Ogun State, Nigeria?

Hypotheses

Ho1: There is no significant difference between students' use of internet of things in Babcock University, IIishan-Remo and Crawford University, Igbesa

Ho2: There is no significant difference between the roles of internet of things on students in Babcock University, IIishan-Remo and Crawford University, Igbesa

Ho3: There is no significant difference between the impact of internet of things on students in Babcock University, IIishan-Remo and Crawford University, Igbesa

Ho4: There is no significant difference between places where internet of things can be applied in Babcock University, IIishan-Remo and Crawford University, Igbesa.

Ho5: There is no significant difference between students' challenges of internet of things in Babcock University, IIishan-Remo and Crawford University, Igbesa.

Methodology

The study is correlational study designed to investigate the role of the role of internet of things in education: Uses and ways IoT affects student's learning. The population of the study is 88 year two students in the department of education, School of Education and Humanities, Babcock University, IIishan and 65 year two students in the department of educational technology, School of computer and Information science, Crawford University, Igbesa. A sample of 100 students was used for the study. Simple random sampling techniques was used for the study. The Instrument used for the study was a structured questionnaire titled the role of Internet of Things in Education: Uses and ways IoT affects student's learning (RITEUWIOTASL) with 30 items. For the study, face and content validity were used. Using Pearson product moment correlation, reliability co-efficient of 0.86

was found. The study's statistical methods included the mean and z test.

Results

Research Question 1: What are the uses of the internet of things in tertiary institutions in Ogun State, Nigeria?

Table 1: Uses of IoT

S/N	Items Uses of IoT	SA	A	SD	D	Mean	SD	Total No of Respondents
1	By collecting and analyzing data on students' learning preference, progress, and behaviors, IoT can support the creation of personalized learning paths	76	23	1	-	3.73	0.45	100
2	IoT facilitates efficient management of educational resources including textbooks, equipment, and digital content	82	18	-	-	3.82	0.38	100
3	IoT transform traditional classroom into content	71	29	-	-	3.71	0.45	100
4	IoT generates valuable data on students' performance engagement and learning pattern	64	36			3.64	0.48	100
5	IoT devices contribute to campus security, through the integration of surveillance cameras, access control systems and sensors	92	8	-	-	3.92	0.27	100
	Average Mean					**3.76**	**0.41**	

Table 1 showed that with mean score of 3.76, the study found that IoT devices contribute to campus security, through the integration of surveillance cameras, access control systems and sensors and also IoT facilitates efficient management of educational resources including textbooks, equipment, and digital content.

Research Question 2: What are the roles of internet of things in tertiary institutions in Ogun State, Nigeria?

Table 2: Role of IoT

S/N	Role of IoT	SA	A	SD	D	Mean	SD	Total No of Respondents
1	IoT improves school management efficiency, it takes a lot of paperwork to manage an educational institutions	69	39	-	-	3.93	0.58	100
2	With personalized learning each student gets a learning plan that is based on what they know and how they learn best	58	42	-	-	3.58	0.49	100
3	IoT allows processing terabytes of data simultaneously, opening a lot of applications for schools and colleges safety, tracking students' progress, monitoring, overseeing the professional training specialists and many more	61	39	-	-	3.61	0.38	100
4	IoT in education helps establishments run more efficiently, reducing operating and storage costs in the long run.	45	55	-	-	3.45	0.50	100
5	The global nature of IoT helps education professionals create uniform teaching standards and ensure equally efficient school and college training world wide	78	22	-	-	3.78	0.41	100
	Average Mean					**3.67**	**0.47**	

Table 2 showed that with mean score of 3.67, the study found that IoT improves school management efficiency, it takes a lot of paperwork to manage an educational institutions and the global nature of IoT helps education professionals create uniform teaching standards and ensure equally efficient school and college training worldwide.

Research Question 3: What is the impact of internet of things on students in tertiary institutions in Ogun State, Nigeria?

Table 3: Impact of IoT

S/N	Impact of IoT	SA	A	SD	D	Mean	SD	Total No of Respondents
1	IoT devices can collect data on student's learning styles, preference and progress	66	33	1	-	3.65	0.50	100
2	Smart classrooms equipped with IoT devices such as interactive whiteboards and connected devices, promotes interactive learning	87	13	-	-	3.87	0.34	100
3	The IoT enables students to access a vast amount of information and educational resources throughout the internet	83	17	-	-	3.83	0.37	100
4	IoT technologies support remote and online learning students can participate in virtual classroom, access materials online, and collaborate with peer and instructors regardless of their physical locations.	49	51	-	-	3.49	0.49	100
5	Communication between students, teachers and educational institution is improved through IoT- enabled communication	80	20	-	-	3.80	0.40	100
	Average Mean					**3.73**	**0.42**	

Table 3 showed that with mean score of 3.73, the study found that smart classrooms equipped with IoT devices such as interactive whiteboards and connected devices, promotes interactive learning, IoT enables students to access a vast amount of information and educational resources throughout the internet and communication between students, teachers and educational institution is improved through IoT- enabled communication.

Research Question 4: Are there places where internet of things can be applied in tertiary institutions in Ogun State, Nigeria?

Table 4: Application of IoT

S/N	Application of IoT in Universities	SA	A	SD	D	Mean	SD	Rank	Total No of Respondents
1	Smart campus infrastructure	62	38	-	-	3.62	0.71	8th	100
2	Connected classroom	11	89	-	-	3.11	0.31	10th	100
3	Special education	35	65	-	-	3.35	0.48	9th	100
4	Smart libraries	73	27	-	-	3.73	0.44	5th	100
5	Student attendance and campus security	82	10	8	-	3.74	0.59	4th	100
6	Research laboratories	95	5	-	-	3.95	0.22	1st	100
7	Distance learning	75	23	2	-	3.73	0.48	6th	100
8	Learning management	79	21	-	-	3.79	0.40	3rd	100
9	Mobile application	67	33	-	-	3.67	0.47	7th	100
10	Monitoring students	88	12	-	-	3.88	0.32	2nd	100
	Average Mean					**3.66**	**0.21**		

Table 4 showed that students prefer the following places where internet of things can be applied in the university; Research laboratories, monitoring students, learning management systems, students' attendance, smart libraries, distance learning, mobile application, smart campus infrastructure, special education and connected classroom.

Research Question 5: What are the challenges of internet of things on students in tertiary institutions in Ogun State, Nigeria?

Table 5: Challenges of IoT

S/N	Challenges of IoT	SA	A	SD	D	Mean	SD	Total No of Respondents
1	Financial resources play a crucial role in the integration of IoT devices and software in the education environment. These expenses of purchasing hardware, software licenses and maintenance price of IoT tools, but also spending on the power supply and teacher training	50	50	-	-	3.50	0.50	100
2	The local infrastructure some institutions engage for data storage is likely outdated and unstable to empower connected IoT based solutions	60	40	-	-	3.60	0.48	100
3	Insecure network configurations where devices were not isolated enough and could access various resources of local area networks	91	9	-	-	3.91	0.28	100
4	Without a robust information technology infrastructure, schools may encounter difficulties in setting up and maintaining IoT networks	79	21	-	-	3.00	0.88	100
5	As IoT devices collect and analyze vast amount of data on students, questions, answers, regarding the ownership and usage of data	52	48	-	-	3.52	0.49	100
	Average Mean					**3.51**	**0.52**	

Table 5 showed that with mean score of 3.51, it was found that insecure network configurations where devices were not isolated enough and could access various resources of local area networks, local infrastructure some institutions engage for data storage is likely outdated and unstable to empower connected IoT based solutions and as IoT devices collect and analyze vast amount of data on students, questions, answers, regarding the ownership and usage of data.

Hypotheses

Ho1: There is no significant difference between students' use of internet of things in Babcock University, IIishan-Remo and Crawford University, Igbesa

Table 6: Table of analysis to determine the significant difference between students' use of internet of things in Babcock University, IIishan-Remo and Crawford University, Igbesa

Group	Mean	SD	N	Df	Standard Error	Z – Cal	Z-Crit	Decision
Babcock University	3.82	0.38	50	98	0.08	2.25	1.96	Rejected
Crawford University	3.64	0.48	50					

The result of the table above shows that the calculated Z-score of 2.25 is greater than the critical Z- value of 1.96. As a rule, when the calculated value is greater than the critical value, the hypothesis is rejected. This implies therefore that there is a significant difference between Babcock University students and Crawford University students on the use of internet of things.

Ho2: There is no significant difference between the roles of

internet of things on students in Babcock University, IIishan-Remo and Crawford University, Igbesa

Table 7: Table of analysis to determine the significant difference between the roles of internet of things on students in Babcock University, IIishan-Remo and Crawford University, Igbesa

Group	Mean	SD	N	Df	Standard Error	Z – Cal	Z-Crit	Decision
Babcock University	3.93	0.58	60	98	0.09	3.55	1.96	Rejected
Crawford University	3.61	0.38	40					

The result of the table above shows that the calculated Z-score of 3.55 is greater than the critical Z- value of 1.96. As a rule, when the calculated value is greater than the critical value, the hypothesis is rejected. This implies therefore that there is a significant difference between Babcock University students and Crawford University student's role of internet of things.

Ho3: There is no significant difference between the impact of internet of things on students in Babcock University, IIishan-Remo and Crawford University, Igbesa

Table 8: Table of analysis to determine the significant difference between the impact of internet of things on students in Babcock University, IIishan-Remo and Crawford University, Igbesa

Group	Mean	SD	N	Df	Standard Error	Z – Cal	Z-Crit	Decision
Babcock University	3.83	0.37	50	98	0.48	0.49	1.96	Accepted
Crawford University	3.49	0.49	50					

The result of the table above shows that the calculated Z-score of 0.49 is less than the critical Z- value of 1.96. As a rule, when the calculated value is less than the critical value, the hypothesis is accepted. This implies therefore that there is no significant difference between the impact of internet of things on students in Babcock University, IIishan-Remo and Crawford University Igbesa.

Ho4: There is no significant difference between places where internet of things can be applied in Babcock University, IIishan-Remo and Crawford University, Igbesa.

Table 9: Table of analysis to determine the significant difference between the impact of internet of things on students in Babcock University, IIishan-Remo and Crawford University, Igbesa

Group	Mean	SD	N	Df	Standard Error	Z – Cal	Z-Crit	Decision
Babcock University	3.88	0.32	54	98	0.06	12.22	1.96	Rejected
Crawford University	3.11	0.31	46					

The result of the table above shows that the calculated Z-score of 12.22 is greater than the critical Z- value of 1.96. As a rule, when the calculated value is greater than the critical value, the hypothesis is rejected. This implies therefore that there is a significant difference between the impact of internet of things on students in Babcock University, IIishan-Remo and Crawford University, Igbesa.

Ho5: There is no significant difference between students' challenges of internet of things in Babcock University, IIishan-Remo and Crawford University, Igbesa.

Table 10: Table of analysis to determine the significant difference between challenges of internet of things in Babcock University, IIishan-Remo and Crawford University, Igbesa.

Group	Mean	SD	N	Df	Standard Error	Z - Cal	Z-Crit	Decision
Babcock University	3.91	0.28	50	98	0.13	5.68	1.96	Rejected
Crawford University	3.00	0.88	50					

The result of the table above shows that the calculated Z-score of 5.68 is greater than the critical Z- value of 1.96. As a rule, when the calculated value is greater than the critical value, the hypothesis is rejected. This implies therefore that there is a significant difference between challenges of internet of things in Babcock University, IIishan-Remo and Crawford University, Igbesa.

Discussion of Findings

Syed, Shoukat, Nazar & Mujeeb (2021) [17], found that the internet of things has the potential for students to relax at home and interact with teachers and other students around the world. Digital highlighters and smart whiteboards can transfer class notes to smart phones, laptops and desktops. Haling (2019) [6] found that the influence of technology can be seen in many aspects of education from student engagement in learning and content creation to helping teachers provide personalized content and improving student outcomes.

Muhammad, Ansar, Khalid, Mahmood, Jahangir & Babar (2021) [11] found that IoT helps establish smart cities, smart environment, security, intelligence, industrial control, automation, agriculture, health, education and especially in the higher education sector. To Ibrahim & Muhammad (2023) found that the IoT can support international collaboration in education by bringing together students and educators from different cultures.

Mariana (2017) found that in education, IoT opens new doors for innovative and new ideas which improve both learning as well as teaching. IoT helps teachers for innovative teaching so they can creatively plan their lessons and make students learning, reading more interesting so their concepts will be clearer. Valentine, Svetozar & Katia (2022) found that the internet of things transformed the traditional school environment into a next generation intelligent environment with enhanced and more efficient educational processes. To Huizhen, (2022), communication between students, teachers and educational institution is improved through IoT- enabled

communication.

Bagheri & Siavosh (2016) found that the use of IoT in higher education saves time and brings comfort to students and staff by real-time monitoring of people, things and places and providing relevant feedback to them. Duha, Hasan, Abdul, Mansoor, Ahmad & Yehia (2023) found that unlimited communication through the IoT enables learners, teachers and researchers to work globally. IoT can be used in e-learning systems for various activities to support the learning process. Shahla, Muhammad, Shahbaz, Muhammad, Muhammad, Arshas, (2017) found that for successfully integration of IoT devices in a classroom environment, an education provider may have to face many difficulties like network, bandwidth, reliable Wi-Fi connection, web analytics, security, privacy, availability of devices for students, teacher training and cost of equipment will have to be addressed.

Conclusion

Exploring the role of the Internet of Things (IoT) in education reveals a dynamic intersection of technological advancements and innovative teaching methods. The various ways in which IoT impacts students' learning experiences highlight its potential to transform education. Integrating IoT devices provides a range of applications, from personalized learning to adaptive teaching approaches, fostering increased engagement and knowledge acquisition. As educational institutions adopt IoT technologies, it is essential to responsibly address challenges, particularly regarding security and privacy. Establishing a trustworthy and ethical IoT ecosystem in education requires robust policies and technological safeguards to balance data-driven insights with safeguarding student privacy. Additionally, prioritizing accessibility and inclusivity, especially for students with diverse needs, is crucial for creating an equitable educational environment.

Recommendations

1. Educational institutions should invest in comprehensive professional development programs for educators to enhance their understanding of IoT technologies and their effective integration into teaching practices. This will empower educators to leverage IoT tools to create innovative and engaging learning experiences.
2. Policymakers and educational institutions must collaborate to establish clear policies and guidelines addressing data security and privacy concerns associated with IoT implementations.
3. Foster collaboration between educators, technology developers, policymakers, and other stakeholders to create a cohesive ecosystem for IoT in education.
4. Educational institutions should prioritize the accessibility and inclusivity of IoT applications. This includes considering the needs of students with diverse learning requirements to ensure that IoT technologies contribute to a more inclusive educational environment.
5. Support and encourage ongoing research and innovation in the field of IoT in education. This includes funding research projects, creating collaborative spaces for innovation, and providing platforms for sharing best practices.

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