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THE AWARENESS LEVEL AND THE KNOWLEDGE OF THE BENEFITS OF THE INTERNET OF THINGS AMONG HIGHER INSTITUTIONS IN NIGERIA

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Abstract
This study examined the awareness, benefits, and challenges associated with the adoption of Internet of Things (IoT) in Nigerian higher education institutions. A survey of 374 academic staff from three institutions revealed moderate awareness of IoT technologies and their potential benefits, such as personalized learning, improved resource management, and enhanced security. However, factors like high costs, infrastructure limitations, and institutional readiness were identified as major obstacles. The findings suggest that overcoming these challenges requires focused efforts on securing funding, improving infrastructure, and providing adequate training for faculty and staff. This research provides valuable insights into the potential for IoT integration into Nigeria's higher Education. Recommendations were made for policymakers and educational leaders to encourage IoT adoption and maximise its benefits for students, staff, and institutional management.
Keyword: Internet of Things, Education, Knowledge, Benefits of IoT, Higher Education

Introduction

The concept of the Internet of Things (IoT) is about how objects are connected to the internet, making them "smart" and capable of exchanging data with one another. This interconnectedness allows for enhanced decision-making through data analysis. IoT technologies are already being utilised across various industries, including healthcare, retail, customer service, home automation, environmental monitoring, and industrial computing. As IoT devices become more pervasive, educational institutions are increasingly incorporating them into their systems, recognising their potential to benefit students, teachers, and the educational environment as a whole.

One essential aspect of education is the physical and environmental setting, which significantly influences the quality of learning. According to Hassan, Khan, and Madani (2018), the educational landscape is evolving, and innovative educational environments

are being created that integrate various information and communication technologies to enhance the educational experience and meet the diverse needs of students.

Despite the vast opportunities IoT offers, there are still significant challenges—technical, social, and economic—that need to be addressed. A Cisco report (2020) reveals that wireless technologies currently account for 43% of all networked devices globally. Furthermore, IoT connections have grown dramatically from 6 billion in 2015 and are expected to reach 27 billion by 2025. Of these, 2.2 billion will be mobile IoT connections, with connected vehicles accounting for 45%. Financially, IoT is projected to generate $3 trillion in revenue by 2025. Countries like Japan, the United Kingdom, and the United States have already begun implementing IoT technologies within their educational systems (Kent, Ellis, & McRae, 2023). Numerous institutions, including the University of San Francisco, have also adopted IoT for improving campus security.

There is considerable research on IoT, but its application in Education remains underexplored. In China, for instance, strategic initiatives are underway to promote the development of IoT technologies, particularly in sectors such as transportation and energy. Many of the world's leading companies have invested in IoT research and implementation. In the educational context, utilising open-source or affordable IoT platforms is recommended as a starting point. Once their effectiveness is established, institutions can further integrate IoT solutions. The potential of IoT to enhance Education lies in its ability to improve interconnectivity within academic institutions, which in turn fosters more personalised and dynamic learning environments.

In recent years, the focus of Education has shifted from being teacher-centred to learner-centred pedagogy. Initially, teaching followed a behaviourist model where teachers were seen as the primary source of knowledge, and students were passive recipients (Serin, 2018). This model faced criticism, leading to the adoption of constructivism—an approach that encourages active learning, where students build their understanding rather than merely receiving information from teachers (Feyzi Behnagh & Yasrebi, 2020). Constructivism emphasises student-centred learning, reflection, and the exploration of diverse perspectives (Ekpenyong & Edokpolor, 2016). Collaborative and inquiry-based pedagogies have also gained popularity, with a focus on group work and scientific methods of inquiry (Scager, Boonstra, Peeters, Vulperhorst, &Wiegant, 2016; Nunaki, Damopolii, Kandowangko, & Elya, 2019). IoT's integration into Education could enhance these pedagogical models by enabling more innovative classrooms and facilitating more individualized learning experiences.

In Nigeria, the government has made significant strides in improving Education at both the primary and tertiary levels. The Universal Basic Education (UBE) Act of 2004 led to a significant increase in enrolment, with rates reaching over 90% in 2017 at the primary and junior secondary school levels (Ministry of Education, 2017). At the senior secondary school (SSS) level, the government has implemented several policies aimed at improving access and quality, including the introduction of Free Education in some States. At the tertiary level, the government has focused on reforms, including the establishment of additional public universities, the promotion of Science, Technology,

Engineering, and Mathematics (STEM) Education, and the expansion of Technical and Vocational Education and Training (TVET) (Ministry of Education, 2017). Additionally, the Nigerian government established the National Board for Technical Education (NBTE) to oversee the development of Technical Education in the country. The integration of IoT technology in various educational environments, including classrooms, libraries, and administration, aims to enhance the learning experience and improve efficiency. IoT-enabled classrooms utilise technologies such as interactive whiteboards and bright chairs to engage students and provide instructors with real-time data. Attendance is tracked using RFID or facial recognition systems, and smart chairs gather data on student engagement and mood, helping to personalise teaching (Saini & Goel, 2019; El Mrabet & Ait Moussa, 2017; Ezeofor & Georgewill, 2020; Sittampalam & Ratnarajah, 2019). IoT transforms libraries with features like book recommenders, digitalized borrowing systems, and seat management. QR technology helps prevent theft, and sensors monitor inventory and fire safety (Abuarqoub, Hammoudeh, Uliyan, Abu-Hashem, Murad, Al-Jarrah, & Alfayez, 2017). Libraries can also offer personalised book recommendations based on users' interests (Makwana, 2021), and inventory is managed through sensors and real-time notifications. IoT enables personalized learning through tools that track student progress, fatigue levels, and engagement. Wearables and smart bags enhance learning by providing real-time data on student activities and alerting parents about missed items or school tasks (Zeeshan & Neittaanmaki, 2021). Learners can also engage with e-books and other interactive materials, improving attention span and learning outcomes.

The Internet of Things (IoT) generates vast amounts of data that can be analysed for predicting student performance, reducing dropouts, and clustering learners for collaborative projects. Machine learning and sentiment analysis improve the learning experience by tailoring content to student needs (Daniel, 2019; Reidenberg & Schaub, 2018; Dake & Gyimah, 2023; Scheuer & McLaren, 2012). The Internet of Things (IoT) enhances administrative efficiency in schools by automating tasks such as staff management, asset tracking, energy consumption, and security. It also aids in financial management, including fee collection and risk monitoring. Kim & Lim, 2018; Patel & Jain, 2021; Budding & Wassenaar, 2021) Smart administration systems support real-time updates and centralised management of resources. IoT aids teachers by offering tools for distance learning, curriculum adaptation, and personalised teaching. Wearables and sensors track student activities, enabling teachers to adjust content and teaching strategies in real-time (Karnieli-Miller, 2020; Ozen & Yildirim, 2020; Campbell-Phillips, 2020; Bagheri & Movahed, 2017; and Alassery, 2019).

IoT-enabled hostels improve student accommodation, addressing challenges and enhancing the learning environment through sensor-based systems connected to the broader smart campus infrastructure (Ahmed, 2021). Despite these advancements, Nigerian educational institutions continue to face significant challenges related to infrastructure and technology. Economic difficulties, including high inflation, currency depreciation, and the COVID-19 pandemic's impact, have exacerbated these issues

(Arthur & Arthur, 2016; Aduhene & Osei-Assibey, 2021). As a result, the adoption of innovative technologies, including IoT, remains a low priority for many institutions in Nigeria, despite the urgent need to access the benefits of IoT in Nigerian institutions.

Statement of Problem

In recent years, the Internet of Things (IoT) has emerged as a transformative technological innovation with the potential to revolutionise various sectors globally. Nigerian higher institutions, however, have yet to fully embrace the IoT, despite its promise of enhancing educational outcomes, improving administrative efficiency, and fostering innovation in research. The integration of IoT into University systems could lead to smart classrooms, optimized resource management, enhanced student services, and improved security systems, thus aligning with global educational trends. However, despite the growing global awareness of IoT technologies and their potential benefits, there is limited empirical research exploring their actual impact on the operational and educational performance of Nigerian higher institutions. Therefore, it is essential to investigate the level of awareness about the benefits of IoT in our institutions. This study aims to determine the benefits that IoT can offer in enhancing academic delivery, administrative processes, and student life. This aims to provide a comprehensive understanding of the potential of IoT integration in Nigeria's educational system and recommend its provision and integration.

Objective of the study

1. Determine the level of awareness of the Internet of Things (IoT) among higher education institutions.
2. Assess the participants' knowledge of the benefits of the Internet of Things in higher institutions.
3. Enumerate the factors that can influence the adoption of the Internet of Things in Nigeria's higher institutions.

Research questions

1. What is the level of awareness of the existence of IoT among the academic staff in Higher Education Institutions in Nigeria?
2. How many of the benefits of the IoT for higher education institutions in Nigeria do the participants know?
3. What are the factors that can influence the adoption of the IoT in Higher Education Institutions in Nigeria?

Methodology

The study employed the survey research design. This design was suitable for the study because it allowed for a representative sample through field research and was relatively easy. The research findings from the selected sample could be generalised to the entire population. The study sampled 1,680 academic staff members from three higher

education institutions using a stratified random sampling approach and a purposive sample. Data were collected through a questionnaire (IOTQ) "Internet of Things Questionnaire.'' The data collected for the study were analysed using frequency counts, mean scores, and standard deviations.

Results and Discussion

Research Question 1: What is the level of awareness of the existence of Internet of Things (IoT) among the academic staff in Higher Education Institutions in Nigeria?
The answer to this question is provided in Table 1 below.

Table 1: Mean and Standard Deviation of Level of Awareness of the Internet of Things (IoT) among the Academic Staff in Higher Education Institutions in Nigeria.

S/No	Item	Mean	Standard deviation
1.	Have you ever heard of the term "Internet of Things" (IoT)?	2.41	0.73
2.	Is IoT technology being used at your institution?	2.33	0.74
3.	Are you aware of Smart Classrooms?	2.54	0.79
4.	Are you aware of Campus Management and Automation i.e Smart Lighting, Smart Parking, Smart HVAC (Heating, Ventilation, and Air Conditioning), and Energy Management Systems	2.31	0.79
5.	Security and Safety (Smart Surveillance Cameras, Smart Access Control Systems, Wearable Safety Devices.	2.19	0.78
6.	Smart Libraries, (RFID (Radio Frequency Identification), Smart Book Shelves, Library and Resource Management Systems:	1.91	0.78
7.	Student Engagement and Experience (Smart Wearables, Smart ID Cards, Interactive Kiosks, Mobile Apps)	2.08	0.78
8.	IoT in Educational Assessment (Learning Analytics Tools, Automated Assessment Systems, Adaptive Learning Platforms	2.30	0.91
9.	Environmental Monitoring: Air Quality Sensors, Smart Waste Management, Weather Monitoring Systems,	1.98	0.86
10	Smart Campus Connectivity (IoT-enabled Campus Wi-Fi, 5G/LPWAN Connectivity: IoT in Laboratories and Research (Smart Lab Equipment, Environmental Sensors for Labs:	2.45	0.82
11	Food and Health Services: Smart Vending Machines, Health Monitoring Systems).	2.12	0.87

12	Virtual Learning Environments (VLE) Collaborative Online Platforms, Smart Whiteboards in Virtual Learning:	2.27	0.75
13	IoT for Administrative Functions, Student Attendance Systems, Student Performance Tracking:	2.00	0.85
14	Collaboration with External IoT Systems; Smart Campus Partnerships:	2.08	0.84

The results presented in Table 1 show that the overall mean score for the 14 (statements) items is 2.26. This suggests that, on average, respondents were moderately familiar with or aware of the various Internet of Things (IoT) technologies mentioned. The standard deviations for these items ranged from 0.73 to 0.91, indicating that while there are variations in the respondents' level of awareness of each IoT technology, the results suggest a moderate level of awareness and usage of some IoT technologies in their educational institutions.

Research Question 2: How much of the benefits of the Internet of Things (IoT) to the Higher Education Institutions in Nigeria do the participants know?

Table 2: Mean and Standard Deviation Scores of the Participants on Knowledge of the Benefits of the Internet of Things (IoT) to Higher Education Institutions in Nigeria.

S/No	ITEM	Mean	SD	Remark
1	IoT enables classrooms equipped with smart devices like interactive whiteboards, smart projectors, and automated lighting or temperature control. Personalized Learning:	2.10	0.86	
2	IoT devices can track individual student progress and learning patterns.	2.24	0.88	
3	By collecting data, it can help educators tailor lessons to meet the specific needs of students, ensuring a more personalized learning experience.	2.25	0.83	
4	IoT enables the use of smart textbooks, augmented reality (AR), and virtual reality (VR) to create immersive learning environments that engage students in hands-on learning,	2.18	0.68	
5	Devices like smartwatches or fitness trackers can be used to track students' physical activity, heart rate, and engagement in activities.	2.07	0.79	
6	IoT can facilitate the creation of learning games that students can interact with in real time, increasing motivation and fostering competitive learning.	2.01	0.78	

7	IoT can enable facial recognition systems or RFID tags to automatically record student attendance, reducing administrative work.	2.32	0.93	
8	IoT can automate tasks such as adjusting lighting, temperature, and even controlling equipment like projectors or speakers, creating a seamless learning experience without distraction.	1.93	0.74	
9	IoT devices enable the seamless sharing of learning materials, assignments, and updates in real-time, ensuring students and teachers are always on the same page.	1.78	0.90	
10	IoT fosters collaboration by allowing students to interact via connected devices, enabling group work on projects even if students are geographically dispersed.	2.25	0.94	
11	IoT-powered security systems, such as surveillance cameras, smart locks, and real-time location tracking for students, enhance safety in school environments.	2.03	0.84	
12	In case of an emergency, IoT can trigger alerts and communicate directly with emergency responders, reducing response time and ensuring faster safety measures.	2.27	0.88	
13	IoT-enabled systems collect data about student performance, allowing teachers to monitor progress and identify areas where students need additional support. This data can be analyzed to make informed decisions about teaching strategies and resources.	2.20	0.90	
14	IoT helps optimize resource use in schools. For example, smart sensors can monitor classroom occupancy and optimize energy use, making schools more eco-friendly and cost-effective.	2.44	0.78	
15	In the case of remote or hybrid learning, IoT facilitates the connection between students and educators through smart devices, ensuring that learning continues uninterrupted, no matter where students are located.	2.29	0.81	
16	IoT-enabled platforms support live interaction through video conferencing, real-time chat, and collaborative tools, making remote education as effective as in-person classes.	2.45	0.80	

17	IoT systems can automatically assess student assignments or tests, providing immediate feedback to students and teachers. This allows teachers to focus more on interactive and developmental aspects of teaching.	1.86	0.797	
18	IoT devices can help track teaching performance by analyzing how effectively lessons are being delivered, providing teachers with insights into areas where they can improve or innovate their teaching methods	2.08	0.82	

Table 2 presents the Mean and Standard Deviation scores for each of the 18 benefits of the IoT suggested in the study instrument. The average mean score of the respondents in that section was 2.18, suggesting that the respondents were somewhat familiar with or already aware of the suggested benefits, or they were already engaged with various IoT-related applications in Education. The standard deviation scores ranged from 0.68 to 0.94 for the 18 items, indicating a moderate level of variability in the participants' responses.

Research question 3: What are the factors that can influence the adoption of the Internet of Things (IoT) in Higher Education Institutions in Nigeria?

Table 3: Mean and Standard Deviation Scores of Participants on the Factors influencing the adoption of the Internet of Things (IoT) in Higher Education Institutions in Nigeria

S/No	Item	Mean	SD
1.	IoT adoption requires stable and fast internet networks, which may not be universally available in all Nigerian institutions.	2.24	0.82
2.	The presence of smart devices, sensors, and IoT- enabled equipment is necessary for implementation.	1.93	0.86
3.	IoT devices must be compatible with the current infrastructure in place at the institutions (e.g., learning management systems, databases).	1.92	0.77
4.	The upfront costs of procuring IoT devices, setting up networks, and integrating systems can be a significant barrier.	2.06	0.79
5.	Ongoing expenses for maintaining IoT systems and updating hardware or software can be a financial burden.	2.16	0.74
6.	Availability of grants, government subsidies, or private sector partnerships to support IoT initiatives.	2.05	0.85
7.	The willingness of university leaders to prioritize IoT adoption as part of the institution's strategic goals.	2.26	0.78

8.	National or institutional policies that promote the integration of emerging technologies like IoT into education.	2.04	0.71
9.	The level of understanding among administrators and policymakers about the potential impact of IoT on education may be low.	1.99	0.75
10.	The availability of faculty and staff with the necessary skills and knowledge to adopt and integrate IoT technologies effectively.	1.87	0.74
11.	The reluctance of faculty to embrace new technology due to unfamiliarity or fear of increased workload.	1.90	0.80
13.	Whether students have access to the necessary personal devices (smartphones, laptops, etc.) to interact with IoT systems.	2.14	0.96
14.	The gap between students from different socio-economic backgrounds may influence access to the technology necessary for IoT-based learning.	1.71	0.87

The overall mean score in this section was 2.04, suggesting that the respondents viewed the challenges to IoT adoption in Nigerian educational institutions as moderately significant. The standard deviation scores ranged from 0.71 to 0.96, which indicated slight variation in the responses. The survey results showed that the participants agreed with the suggested barriers to the adoption of IoT in Nigerian higher educational institutions. The challenges that the participants ranked highest were those that centred on finance, infrastructure requirements (such as stable internet), and the need for exemplary institutional leadership.

Discussion/ conclusion

The results in the three tables indicate moderate awareness and some measure of adoption of certain IoT technologies in Nigerian educational institutions. Financial constraints, infrastructure challenges, and lack of institutional support were the main barriers. Educational leaders are somewhat aware of the importance of IoT, but there remains a significant gap in understanding and appreciating its full potential, as well as the strategies required for its integration.

The financial challenge, which encompasses upfront costs and ongoing maintenance, combined with infrastructure gaps (such as the need for stable internet), poses the most significant obstacle to IoT adoption. Additionally, policy support and leadership prioritisation will be key in overcoming these obstacles. To overcome these barriers and increase the adoption of IoT, the following were recommended:

1. Nigerian educational institutions will need to focus on making funds available to improve/ provide internet infrastructure, ensuring

compatibility with existing systems.

2. Fostering a stronger understanding of the benefits of the IoT among administrators, faculty, and students.

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