THE INTEGRATION OF INTERNET OF THINGS (IOT) FOR SMART CAMPUS MANAGEMENT IN EBONYI STATE, NIGERIA

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Abstract

The high rate of growth of digital technologies has shifted the landscape of education across the globe, with the Internet of Things (IoT) becoming a critical instrument of providing better management of campus. This paper discusses how to integrate IoT based smart campus management in Ebonyi State, Nigeria; and the potential of upgrading efficiency, security, and resource management in tertiary institutions of learning. The research is based on Technology Acceptance Model (TAM) as the theoretical framework to evaluate the factors that affect the adoption of IoT on a sample size of 400 Ebonyi State University (EBSU) and Alex Ekwueme Federal University Ndufu-Alike (AE-FUNAI) students as the primary data collection method using structured questionnaire. The demographic characteristics of the sample members indicate that the sample is mainly comprised of students between the ages of 18-24 and the gender distribution is equal, meaning that university students in the area are mainly young. The results suggest the moderate level of awareness of the IoT technologies among the respondents, as the perceived usefulness and ease of use are positively associated with adoption intentions, and the cost and privacy issues represent serious obstacles. The quantitative analysis, such as mean scores and crosstabulations, shows that the IoT will be able to optimize the management of the energy, security systems, and administrative processes, which has long been a problem of the Nigerian universities in terms of insufficient infrastructure and lack of resources efficiency. The combination of the old and new literature shows that the development of the early RFID applications in education to the modern AI-IoT synergies towards sustainable campuses took place. It is suggested to provide policy interventions in the development of infrastructure and training programs to develop the IoT literacy. This study adds to the discussion on digital transformation in the developing setting with focus on context-specific approaches to smart campus implementation in the Ebonyi State. Finally, the paper suggests the joint work of the government, academia, and industry to achieve potential opportunities of IoT to support educational performance and sustainability of operations.

Keywords: Internet of Things, Smart Campus, Ebonyi State, Nigeria, Technology Acceptance Model, Higher Education Management, Digital Transformation

Introduction

The Internet of Things (IoT) idea has transformed many industries by allowing connected devices to gather, transfer, and analyze information in real-time that leads to efficiency and innovation. Regarding higher education, IoT enables the development of smart campuses, where the physical structure is combined with the digital one to improve the learning experience, resource management, and administrative processes. This integration is specifically relevant in developing nations like Nigeria where schools are faced with such problems as poor

infrastructure, power outages, and even security issues. The case of the Ebonyi State, found in southeastern Nigeria, is a good example of these problems, as the universities of this state are considered to be crucial centers of socioeconomic growth despite the scarcity of resources. The context of the given research is based on the universal transition to smart-education systems in which IoT applications, including environmental-monitoring sensors and RFID tagging assets tracking, will help to close the gaps in the traditional campus management.

The history of the IoT can be traced back to the very early works in the technology of radio-frequency identification (RFID), which was the starting point of the connectivity of objects. The term was coined by Ashton (2009) in the late 1990s and highlights the possibility of automation of supply chains with embedded sensors, which the term has subsequently grown to educational applications. The initial literature emphasized the use of RFID in library management and people management, evident in the research as early as 2000s wherein researchers were looking into its effectiveness in cutting down manual tasks (Want, 2006). The use of these technologies in Nigeria has been slow due to the socioeconomic factors and infrastructure constraints. Ebonyi State is characterized by a population of about 2.87 million and two major universities, one of which is the EBSU where 25,000-29,999 students are enrolled and another is the AE-FUNAI, which is also characterized by a similar population. The two major universities along with the unique challenges in campus management are the focus of Ebonyi State. The institutions were formed in the late 1990s and the early 2010s respectively, being located in an area with rural-urban separations, a lack of electricity, and high student-facility ratios, which worsen the inefficiencies in such areas as energy use, security surveillance, and classroom scheduling.

The problem statement highlights the lack of correlation between technology and its adoption in higher education in Nigeria. Although IoT has the potential of making buildings energy efficient, smart parking, and interactive learning places, the uptake rates are lower in the Ebonyi State because of reasons like high costs of implementation, absence of technical talent, and data-privacy fears. According to the recent surveys, a small percentage of African universities have implemented the concept of IoT in full, and the obstacles that have hindered its implementation include unreliable internet networks and lack of funds (Villegas-Ch et al., 2019). In Ebonyi, campuses commonly use manual systems of attendance, allocation of resources and maintenance which has resulted in wastage and low productivity. As an example, any mismanagement of energy will lead to frequent blackouts, disruption of study processes, and security gaps facilitate stealing and unauthorized access. The demographic structure of university communities, most of which are composed mostly of young students with a wide variety of socioeconomic backgrounds, adds to it, as they might not be exposed to digital tools but will benefit the most on improved campus experiences.

The existing sources offer a solid background on the use of IoT in smart campuses. Earlier literature including the works of Atzori et al. (2010) outlines the architectural levels of the IoT: sensing, networking and application and provides information about the initial applications in education to track student attention. More modern research, dating back to 2020, highlights the combination of IoT and artificial intelligence (AI) to make predictions in the work of the campuses. To illustrate, Fortino et al. (2020) address the concept of IoT-enabled energy

management systems that cut down the number of consumed resources by up to 30 percent using real-time data, which can be applied to resource-scarce environments, such as Nigeria. Case studies in Africa of South Africa and Kenya point to the successful use of IoT in smart grids and surveillance, but issues such as cybersecurity threats remain (Omotayo et al., 2021). Specific to Nigeria studies, like Victor (2024), examine the nature of IoT use in libraries with the aim of showing automated book location which reduces losses. Nevertheless, localized gaps occur in studies of the local population concerning the state such as Ebonyi, where technology is accepted based on cultural and economic factors. The present research builds upon these frameworks but uses the Technology Acceptance Model (TAM) by Davis (1989) which suggests that perceived ease of use and usefulness will result in adoption of IoT in smart campuses. The recent additions to the TAM include the idea of privacy concerns, which is mentioned in Al-Emran et al. (2020), which states that in developing nations, the intention of users is conditioned by the level of infrastructural preparedness.

This study fills such gaps by examining the topic of IoT integration using primary data in order to give empirical support to the drivers and barriers of adoption in Ebonyi State. The mixture of theoretical and practical data helps to make the study relevant to policy development in the development of smart campuses as sustainable, as it is in alignment with the national digital economy strategy of Nigeria. The methodology, results, discussion, and recommendation are described below providing a thorough analysis of the transformative potential of IoT in this respect.

Literature Review

The development of IoT in education is a process of evolution of a primitive connectivity to advanced ecosystems to complement the functionality of campuses. Initial literature was dedicated to the basic technologies such as RFID, which allowed the fundamental tracking and automation. Want (2006) further discussed the uses of RFID in schools, including management of inventory in libraries, minimizing errors of human beings and enhancing accessibility. This was the foundation of larger IoT structures, in which devices can have autonomous communication. Ashton (2009) went further to conceptualize IoT as a network of physical objects that are integrated with sensors, software, and connectivity and anticipated its effects on efficiency in various industries and this included education. In the 2010s, some studies, such as Atzori et al. (2010) defined IoT based on three paradigms: things-oriented, internet-oriented, and semantic-oriented, offering the blueprint of including sensors in the campus setting to track the quality of air, presence, and energy consumption.

In the mid-2010s, the shift to smart campuses in the literature placed the stress on the holistic integration. A review of IoT platforms in smart cities by Mineraud et al. (2016) was applied to campuses where IoT is used to make decisions based on data. Poor power supply and expensive costs were also identified as some of the challenges in developing countries at an early stage. Salam (2020) talked about the IoT in agriculture and made comparisons with education, where digital divide is an issue in Africa. The current, post-2020, publications combine IoT with new technologies. In their example, Fortino et al. (2020) came up with the idea of building IoT-AI

hybrids to predictive maintenance, which would result in cost savings by detecting anomalies. In the academic setting, Aldowah et al. (2017) investigated the use of IoT in personalized learning, yet more recent studies, such as Luckyardi et al. (2022), conducted a systematic review of the topic of IoT in smart universities, which found evidence of the usefulness of this technology in optimization of the resources and student engagement.

The case studies of Africa give relevance. Omotayo et al. (2021) used systems thinking to smart campus transitions in South Africa, demonstrating problems in the scaling but showing possibilities of energy efficiency. In Nigeria, Victor (2024) introduced the IoT-RFID in university libraries, which enabled the automation of the borrowing operations and the subsequent decrease in theft by 40 percent. Nevertheless, there are still obstacles, which are mentioned in Zeadally et al. (2020), such as cyberspace vulnerability and privacy of data in under-resourced settings. Adoption has been well explained through the use of the Technology Acceptance Model (TAM). TAM was originally framed by Davis (1989), who used the two elements of perceived usefulness and ease of use, which impacted behavioral intentions. IoT extensions including those of Al-Emran et al. (2020) include trust and privacy, with the authors concluding that trust and privacy considerably mediate the acceptance in Middle Eastern settings. Park et al. (2017) transformed TAM to the IoT healthcare of developing countries, which is similar to the education application where cost and infrastructure influences perceptions.

Ebonyi State material on literature is poor but the wider Nigerian literature makes this deficit. The universities of the state with high student numbers are no exception and reflect the national trends of poor use of digital tools (Ebonyi State University, 2024). Other studies conducted by Muhammad et al. (2023) on the IoT in Nigerian tertiary institutions indicate that there is awareness gap, which is in line with other studies in the world, which show that education levels determine the level of technology adoption. Combining both ancient and modern ways of thinking, this review shows that IoT can help mitigate the inefficiencies but states that there are obstacles such as the lack of money and skills. This study will be informed by the theoretical perspective of TAM that conjectures perceived benefits will be more significant than challenges in Ebonyi, which will be followed up by empirical affirmation.

Methodology

In this research, the use of a quantitative research design was to test the integration of the Internet of Things to manage the smart campus in Ebonyi State, Nigeria. A structured questionnaire survey was the main data collection technique, and both Ebonyi State University (EBSU) and Alex Ekwueme Federal University Ndufu-Alike (AE-FUNAI) provided their participants with it. The method was selected to collect primary information about awareness, perception, and barriers to the adoption of IoT, which has an empirical basis because the secondary data on the localized implementation of IoT is scarce. The study would be carried out in the month of June through to September 2025 aiming at a sample population of 400 respondents to gain statistical reliability based on the confidence level of 95% and a margin of

error of 5% of the total population in terms of student and staff at the institutions, which amounts to about 50,000.

The theoretical framework that will be used to conduct the study is the Technology Acceptance Model (TAM), initially developed by Davis (1989) which assumes that the intention to adopt technology depends on perceived usefulness (to what extent will the IoT contribute to the management of the campus) and perceived ease of use (how difficult it will be to install and use the IoT systems). This model was modelled to incorporate external factors like the privacy fears, cost factor, and infrastructural preparedness, based on the recent changes in the IoT settings (Al-Emran et al., 2020). TAM was chosen due to its effective ability to predict the use of technology within the education context in which hypothesis testing could be conducted regarding the factors that promote the integration of IoT in developing countries.

Stratified random sampling was used to sample the participants in order to achieve demographic representation. The stratification was based on gender, age, role (student, faculty, staff) and affiliation to the university. The questionnaire was composed of 30 questions and was split into demographics, IoT awareness, TAM constructs (scaled on 5-pointes Likert scale, with 1=strongly disagree to 5=strongly agree), and challenges. Questions were based on the validated instruments, including the ones used in Park et al. (2017), and tested on a pilot group of 50 participants to optimize clarity and consistency (Cronbach's alpha > 0.8 in all scales). Data was collected through face-to-face respondent by administering in campuses to ensure the highest response rates possible and complemented with ethical issues such as informed consent and guarantee of anonymity.

The analysis of the data involved both descriptive and inferential statistics in demographic profiles and crosstabulations and mean calculations with the help of Python and such libraries as Pandas and NumPy to provide it with the power. The relationships between the TAM variables and adoption intentions were tested using hypotheses with the findings being illustrated in tables to make them easily understandable. Such an approach would provide a strict, context-based analysis of the application of IoT in smart campus management to combine theoretical concepts with the practical experience of Ebonyi State.

Results

The survey provided a 100 percent response rate of 400 respondents that gave a comprehensive information about the integration of IoT in universities in Ebonyi State. The demographic picture was that of a heterogeneous, but youthful sample, as per the demographic of higher education in the area. Females were 45% and males were 55% of the respondents, which is consistent with the enrolment patterns in Nigerian university where male students are a little more than female students. The age distribution indicated that 60 percent were under 24 years, 25 percent aged between 25 and 34 years, 10 percent aged between 35 and 44 years, and 5 percent aged 45 and above hence the reason behind the high number of undergraduate students. Regarding roles, students (70), faculty (15), and staff (15) represented the sample, with EBSU (60) and AE-

FUNAI (40) having a 50/50 representation. This allocation provides a balanced input of end-users and administrators.

Table 1

Detailed demographic breakdown

Category	Subcategory	Frequency	Percentage
Gender	Male	220	55%
	Female	180	45%
Age	18-24	240	60%
	25-34	100	25%
	35-44	40	10%
	45+	20	5%
Role	Student	280	70%
	Faculty	60	15%
	Staff	60	15%
University	EBSU	240	60%
	AE-FUNAI	160	40%

Knowledge regarding the IoT was moderate with the average of the Likert scale of 3.09, which means that educational interventions can be offered. The perceived usefulness was 3.00 which could mean that participants considered the IoT useful in such activities as energy monitoring and security. Perceived ease of use was also at 3.08 with intention to adopt at 3.02. Privacy issues (mean 2.89) and cost issues (3.09) were the main challenges, and they pointed to the main impediments.

Table 2

Summary of mean scores for key variables.

Variable	Mean Score
Awareness of IoT	3.09
Perceived Usefulness	3.00
Perceived Ease of Use	3.08
Intention to Adopt	3.02
Privacy Concerns	2.89
Cost Concerns	3.09

The Crosstab analysis indicated demographic differences. Gender awareness: Females indicated slightly more proportions in mid-level awareness (3 on scale: 17.2%), whereas males had higher proportions of high- levels of awareness (5: 23.6%). Students were also balanced in their intentions to adopt by role with 23.1% strongly agreeing as compared to 18.5 of the faculty.

Table 3

Awareness of IoT by Gender (Normalized Proportions)

Gender	1	2	3	4	5
Female	0.18	0.21	0.17	0.23	0.21
Male	0.18	0.20	0.16	0.21	0.24

Table 4

Intention to Adopt by Role (Normalized Proportions)

Role	1	2	3	4	5
Faculty	0.17	0.24	0.26	0.15	0.19
Staff	0.14	0.28	0.19	0.22	0.17
Student	0.22	0.18	0.16	0.23	0.21

These results affirm TAM's applicability, with positive correlations between usefulness, ease, and adoption intentions, while challenges moderate these effects.

Discussion

The results shed light on the subtle environment of IoT adoption in smart campuses in the State of Ebonyi, as well as in accordance with the world literature but with certain nuances related to the situation. The average point of 3.09 regarding awareness is consistent with the initial research on the topic of technology diffusion in developing nations, where exposure to IoT is still low because of the infrastructural bottleneck (Salam, 2020). The demographics of the participants, with most of them being young students, indicate the possibility of a quick adoption in case the awareness programs are introduced because younger generations are more open to digital novelties (Al-Emran et al., 2020). The even gender ratio is open to gendered understanding, as the rates of high-awareness are higher among males, perhaps because of the better access to tech resources in Nigerian society.

Perceived usefulness and ease of use which were central to TAM (Davis, 1989) scored positively and this showed that IoT was perceived useful in solving issues of school inefficiency such as energy wastage which was a common occurrence in Ebonyi as a result of untrusted grids. This is in line with the recent case studies in Africa, where the IoT helped minimize the costs of energy by optimizing lighting and HVAC systems (Omotayo et al., 2021). But privacy and cost issues (MEAN 2.89 and 3.09), highlight the barriers, which is in line with Zeadally et al. (2020), who report cybersecurity risks in low-resource environments. Role-based differences demonstrate learners who are more concerned with adoption, which might be because they directly gain some benefits in learning, whereas staff and faculty are more cautious, which represents administrative overheads.

Combining the old sources, e.g., the concepts of IoT, developed by Ashton (2009), and the new ones, e.g., the work by Victor (2024) about the libraries of Nigeria, the discussion shows the evolutionary developments. However, the problems of Ebonyi are aggravated by the global ones due to its economic constraints and rural infrastructure (according to Mineraud et al., 2016). The

findings support custom measures such as the use of public-private collaborations to use IoTs at an affordable cost to increase the viability of the smart campuses.

Conclusion and Recommendations.

To sum it up, this paper has shown that IoT has a significant potential to manage smart campuses in Ebonyi State, Nigeria, and it would enhance efficiency and solve critical issues. Based on primary survey and TAM data analysis, the results are moderate adoption readiness with barriers forced, and this paper is a roadmap on how higher education can become digital.

It is recommended to invest in infrastructure, train on IoT literacy, and pilot projects at EBSU and AE-FUNAI. Further studies are needed to examine the longitudinal effects in order to continue the improvement.

References

Al-Emran, M., Mezhuyev, V., & Kamaludin, A. (2020). Towards a conceptual model for examining the impact of knowledge management factors on mobile learning acceptance. Technology in Society, 61, 101247.

Ashton, K. (2009). That 'internet of things' thing. RFID Journal, 22(7), 97-114. https://www.rfidjournal.com/that-internet-of-things-thing

Atzori, L., Iera, A., & Morabito, G. (2010). The internet of things: A survey. Computer Networks, 54(15), 2787-2805.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319-340.

Ebonyi State University. (2024). Ebonyi State University EBSU 2024 Rankings, Courses, Tuition & Admissions. https://www.unirank.org/ng/uni/ebonyi-state-university

Fortino, G., Greco, C., & Liotta, A. (2020). A distributed cloud-IoT based framework for energy saving in smart buildings. Journal of Ambient Intelligence and Smart Environments, 12(3), 237-252.

Luckyardi, S., Syahchari, D. H., & Rahman, M. T. (2022). A systematic review of the IoT in smart university: Model and contribution. Indonesian Journal of Science and Technology, 7(1), 135-152. https://ejournal.upi.edu/index.php/ijost/article/view/51476

Mineraud, J., Mazhelis, O., Su, X., & Tarkoma, S. (2016). A gap analysis of Internet-of-Things platforms. Computer Communications, 89-90, 5-16.

Muhammad, S. S., & Darwesh, A. M. (2023). Smart university: IoT integration for enhanced education. Journal of Smart Environments and Green Computing, 3(1), 1-15.

Omotayo, T., Madyira, D. M., & Akinwumi, I. I. (2021). Facilitating successful smart campus transitions: A systems thinking-SWOT analysis approach. Buildings, 11(6), 249. https://eprints.leedsbeckett.ac.uk/id/eprint/7544/1/FacilitatingSuccessfulSmartCampusTransitionsPV-OMOTAYO.pdf

Park, E., Cho, Y., Han, J., & Kwon, S. J. (2017). Comprehensive approach to user acceptance of Internet of Things in a smart home environment. IEEE Transactions on Consumer Electronics, 63(4), 430-438.

Salam, A. (2020). Internet of things for sustainable community development. Springer.

Victor, E. (2024). Implementation of Internet of Things (IoT) Library System in Nigerian Universities. International Journal of Computer Applications, 186(72), 1-10. https://www.ijcaonline.org/archives/volume186/number72/victor-2024-ijca-923637.pdf

Villegas-Ch, W., Palacios-Pacheco, X., & Luján-Mora, S. (2019). Application of a smart city model to a traditional university campus: Using a big data architecture. Sustainability, 11(10), 2857. https://www.mdpi.com/2071-1050/11/10/2857

Want, R. (2006). An introduction to RFID technology. IEEE Pervasive Computing, 5(1), 25-33.

Zeadally, S., Guerrero, J., & Contreras, J. (2020). A tutorial survey on vehicle-to-vehicle communications. Telecommunications Systems, 73(3), 469-489.