© JAN 2026 | IRE Journals | Volume 9 Issue 7 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV9I7-1713555

Awareness and Utilisation of Internet of Things (IoT) for Interactive Learning among Undergraduates in the University of Ilorin.

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Abstract- Rapid advancements in Information and Communication Technologies (ICTs) have significantly transformed educational practices, with the evolution of the internet from a medium of communication to the Internet of Things (IoT), enabling interconnected devices to exchange data with minimal human intervention and support interactive learning environments. This study investigated undergraduates' level of awareness, utilisation, and attitude toward the use of IoT for interactive learning at the University in Ilorin, Nigeria, using a descriptive survey research design. Data were collected through a structured questionnaire administered to 118 undergraduate students drawn from the the Faculty of Engineering and the Faculty of Communication and Information Sciences. The collected data were analysed using frequency counts, percentages, and mean scores, while hypotheses were tested at the 0.05 level of significance. The findings revealed that the undergraduates possessed a high level of awareness of IoT tools for interactive learning, with 70.9% indicating awareness, and demonstrated a high level of utilisation, as reflected by a grand mean score of 3.35 on a 4-point scale. Students reported that the use of IoT-enhanced internet resources improved their understanding of complex concepts ($\bar{X}$ = 3.53) and exhibited a positive attitude toward the adoption of IoT for interactive learning ($\bar{X}$ = 2.96). Hypothesis testing showed no significant differences in awareness or utilisation of IoT for interactive learning based on gender or faculty. The study concluded that undergraduates at the University in Ilorin were well-prepared and receptive to emerging IoT technologies, with adoption appearing inclusive across demographic groups, implying a strong institutional readiness for technology-driven learning environments.

I. INTRODUCTION

There have been rapid developments in information and communication technologies (ICTs) in the 21st century. These developments have impacted human endeavours, operations and services of industries and institutions, including libraries (Kalu & Ochepa, 2021). Arguably, the advent of the internet is the most important and influential development in Information Communication Technology (ICT). The internet now has a distinctive influence in various aspects of human life, including relationships, interactions, manufacturing and services. Apart from providing a veritable platform for the effective and efficient promotion of workflow and services, the rapid growth of the internet globally lies in its ability to foster and shape human relationships and communication. In this regard, the advent of mobile devices and social media has made internet use a part of life for a good number of the world's population. The availability of broadband internet connections, more devices with Wi-Fi capabilities, affordability at a lower cost and the proliferation of smartphones have also contributed to the growth of the internet. For libraries, the internet now makes it possible for electronic packaging and virtual acquisition of information resources, online reference services, and electronic cataloguing, as well as online dissemination of required information resources, among others.

Information and communication technology serves as the foundation stone of the modern world, with the potential to revolutionise educational methods. There is an increasing demand on educational institutions to employ ICT to educate students in the skills and knowledge they will need in the twenty-first century (Shabir & Javed, 2022). The intervention of information and communication technology is redefining the way students learn. It is making the process of learning more efficient and effective for students and teachers. ICT tools in education make it easier for teachers to use the best strategies to bring out the best in their students (Kilag et al., 2022). ICT improves teaching and learning, and its importance for teachers in performing their role as creators of pedagogical environments. ICT helps a teacher to present their teaching attractively and enables learners to learn for the learners at any level of educational programmes (Kilag , 2023). According to Ahmad & Sheikh (2021), the significant impact of Information Communication Technology (ICT) in education may be attributed to factors such as: ICT in education provides access to all types of learners. The provided materials can benefit all students. Even students with special needs can benefit from its use. ICT also address issues such as the digital divide, allowing even the poor to gain access to tools that meet their educational needs and improve learning.

Information and communication technology also encourages collaboration when children work together as a team. When you discuss, talk, and study together, you improve your communication skills. To test it, all you need is a laptop, tablet, or desktop computer. ICT tools facilitate language development by encouraging communication. Children become more involved and involved in learning as ICT is integrated into education and their tools, all thanks to technologies that make learning fun, creative, and playful, improving learning in many ways. As a result, students learn more effectively, which leads to knowledge retention; ICTs foster higher-order thinking and reasoning skills. These abilities allow for assessment, planning, monitoring, control, reflection, and so on. Students must be able to discuss, test, and evaluate the strategies and methods they use to use ICT. However, Echedom and Inemotimi (2021) observed that in recent times, the internet has leapt forward from the "internet of communication" to the "internet of things", making it possible to connect objects and transfer data with or without human intervention. The 'internet of communication' promoted better communication and improved services, but with some form of human intervention. Herein lies the distinctiveness of the 'internet of things' connecting objects using sensors and networking capabilities with very minimal or no human intervention. The evidence of the origin of the term "Internet of Things" is visibly found back in the late '90s from the work of one of the British technology pioneers, Keven Ashton 2009, who described it as the system that employs the use of sensors for connecting physical world objects to the Internet (Shi et al., 2021).

He nominated this term to expound on the process of using Radio Frequency Identification (RFID) labels for auto-tracking goods without considerable human interference. Recently, the Internet of Things has significantly expanded to various objects, devices, and everyday items. It has received wider recognition in various disciplines, including computer science, engineering, business, and education (Asad et al., 2022). The role of the Internet of Things (IoT) in education is not only limited to the teaching and learning process, but also serves educational institutes to manage and track their key resources effectively (Matthew et al., 2021). It enhances students' access to information within and outside of the classroom and provides an interactive and active learning environment (Lombard et al., 2021). It enables students to get a variety of opportunities to learn in a collaborative environment, doing hands-on practices and demonstrating notable academic improvement in terms of conceptual understanding as well as technical aspects of learning (Laid & Adlaon, 2025). In addition to that, the IoT-based smart classrooms and laboratories in higher education brought a paradigm shift in the teaching and learning process, especially in engineering and software engineering domains. The IoT allows humans and things to access from anywhere, anytime, and any place the link with anything and to any person without a specific path and service (Singh, 2023).

Excitingly, it is worth arguing that the existing education system has to make necessary amendments to equip it with the modern tools and technologies to implement a modern curriculum for digitalizing students' learning (Mateo-Berganza et al., 2022). This requires the use of modern resources such as digital smart laboratories and smart devices to meet the diverse learning needs of the students of the twenty-first century, who can offer their services better fit to the current industrial and technological era (Ong & Annamalai, 2023). In this regard, students need to be given hands-on exposure to handling smart devices to develop the necessary understanding and skills through enhanced communication, connectivity, and an active learning approach.

Literature Review

The Internet of Things (IoT) is a phrase widely considered to have been coined by Kevin Ashton at the end of the twentieth century (Alaba, 2024). The term "Internet of Things" originated in 1999 with the work of two Massachusetts Institute of Technology (MIT) research labs: the Auto-ID Centre and the MIT Media Lab. Kevin Ashton and Neil Gershenfeld, respectively, argued for the enfolding of things into the Internet in an active role, either in terms of making the world comprehensible for things or adding things to the Internet (Darmois et al., 2023). In this context, the IoT was seen as a paradigm shift from the Internet of discrete desktop or mobile computers to a broadly defined ambient connectivity permeating everyday material artefacts, thereby granting them agency visible to humans. Today, computers, and therefore the Internet, are nearly wholly dependent on humans for information. The problem is that people have limited time and accuracy, all of which means they are not very good at capturing data about things in the real world, and that is a significant challenge. Such a claim stems from the rapid expansion of the Internet and the potential embedded in the massive amounts of data found online, alongside the development of more nuanced data processing for effective decision-making in an increasingly complex world.

According to Ashton (2009), making informed choices in all areas of life, from how much exercise to do to who to vote for, must arise from a data-mined cache of information that can account for and rationalise specific outcomes and consequences. For Ashton, this entails developing a system that helps process data by masking the possibilities of emotion and instinct and reifying enlightenment and scientific rationalist approaches. Importantly, Ashton argued that humans are flawed and therefore compromise their role in data entry for our massive networked systems, which implies that our machines are also flawed. He maintained that machines are better at objectively capturing information about the real world and that harnessing their potential can assist humans in making better decisions. Seberger (2022) affirmed, “We need to empower computers with their own means of gathering information, so they can see, hear, and smell the world for themselves, in all its random glory.” This vision, however, reveals both the possibilities and problems of how humans relate to machines in daily life. The resulting dynamic can be described as a decentring of humans from the position of sole enunciators of agency, with serious implications for conceptualisations of sociability, agency, and identity (Maclean, 2020). Such imaginings are polarised; while some evoke fictional artificial intelligences such as Skynet, others argue that Ashton’s vision is overly deterministic and rudimentary to account for the complex relationships between humans and machines. Machines require discipline from humans, yet humans must also adopt and adapt to the needs of mechanisation. Historically, during industrialisation, machines demanded repetitive embodied labour. The Luddites who emerged during that era to destroy machines “were not against machines per se, or technological progress”; rather, they were concerned about the impact of machines and their integration into workplaces on “their way of life and mechanisms of solidarity and workmanship nurtured over generations” (Standing, 2016). They were rightly worried about how machines altered embodied and emotional connections and actions. In modern times, humans have adapted their routines around computers and mobile devices, often prioritising technological interactions over face-to-face communication. With the miniaturisation of electronics and the evolution of mobile phones into smart devices, the perception, whether accurate or not, persists that machines are adapting to us.

The IoT, therefore, represents a system of interconnected computing machines designed to automate and simplify various aspects of daily life while facilitating data-driven decisions to ensure that activities are executed using the most resource-effective methods. Although the notion of IoT has been widely recognised in academia since the late 1990s, its development remains in the early stages (Jameel et al., 2024). The total number of connected devices worldwide has been projected to reach tens of billions, reflecting an exponential growth trend expected to continue into the foreseeable future (Jameel et al., 2024). From its inception, the number of connected devices has risen dramatically, reaching an estimated 50 billion by 2020 (Mahbub, 2020). The Internet of Things marks a new revolution in the evolution of the Internet. Objects can make themselves recognisable and gain intelligence by making or enabling context-related decisions because they can communicate information about themselves. They can access information aggregated by other devices or act as components of complex services. This transformation coincides with the emergence of cloud computing and the transition to IPv6, which offers an almost unlimited addressing capacity (Mykola et al., 2023). The overarching goal of IoT is to enable connectivity among devices, objects, and individuals anytime and anywhere, ideally through any network, path, or service.

IoT technologies differ from previous innovations because they are ubiquitous, intelligent, and autonomous (Vermesan et al., 2022). Advances in IoT have emerged as a major strategic technological trend (Waleed, 2024). Ubiquitous sensors and the ability to bridge the gap between the physical and digital worlds form the conceptual basis for a new technological paradigm. The integration of sensors into objects and the use of Machine-to-Machine (M2M) communication enable billions of devices to connect through existing Internet infrastructure. As the physical world rapidly transitions online, IoT continues to generate both excitement and anxiety globally (Ahmad & Zulkifli, 2022). There are clear indications that IoT will transform multiple sectors, including higher education. Universities are now positioned to lead the technical development and innovation models associated with IoT, preparing future leaders while addressing TIPPSS concerns: Trust, Identity, Privacy, Protection, Safety, and Security associated with IoT applications.

Fundamentally, IoT is a global network connecting devices, objects, and things to Internet infrastructure, allowing them to communicate and interact with their internal and external environments through information-sensing devices and specific protocols (Singh, 2023). It extends the communication spectrum beyond human-to-human (H2H) interaction to include human-to-thing (H2T) and thing-to-thing (T2T) communication (Lv & Li, 2021). The IoT thus comprises distinctively addressable physical entities with sensing, processing, and actuation capabilities that interoperate and communicate through the Internet as a unified platform (Yadav & Pawan, 2024). Its core objective is to enable continuous connectivity between objects and individuals, regardless of time, location, or network type. IoT is increasingly recognised as the next stage of Internet evolution, allowing everyday objects to connect and interact to achieve diverse goals. The concept refers to the expanding network of physical objects equipped with IP addresses for Internet connectivity, facilitating communication between these objects and other Internet-enabled systems (Singh, 2023).

IoT enables remote monitoring and control of physical environments, allowing objects to act in coordination through ambient intelligence (Mahmood et al., 2020). Such communication can enhance fields like e-commerce by providing high-quality, real-time data for decision-making. Moreover, IoT devices often sense and report their surroundings to both machines and humans (Mazhar et al., 2022). The paradigm supports multiple human-centric applications, including smart healthcare, smart homes, smart energy, smart cities, and smart environments (Chataut et al., 2023). Through wireless connectivity, IoT creates unified communication between people and objects (Kopetz & Steiner, 2022). It is best understood through three intersecting models: the web-based (middleware), the things-based (sensors), and the semantic-based (knowledge) models (Ovidiu et al., 2022). As research and development efforts continue, IoT is envisioned to facilitate the convergence of real, digital, and virtual spaces, creating smart environments in energy, transport, urban development, and education (Li et al., 2022).

Ane et al. (2020) predicted that IoT will directly and indirectly influence teaching and learning processes, enhancing the quality of education by enabling teachers to meet diverse student needs in measurable and engaging environments. The integration of IoT in higher education institutions provides opportunities for interdisciplinary innovation, development of IoT technologies, and the nurturing of ethical leaders for the future IoT-driven economy. According to Matthew et al. (2021), IoT will bring about changes in educational technology, teaching methodologies, learning processes, and institutional management. It supports progressive evaluation systems, the integration of teaching platforms, and the development of educational middleware. This evolution enhances convenience for students and improves teaching efficiency for instructors. By enabling real-time data analysis, IoT empowers educators to focus on meaningful learning rather than routine administrative tasks. It also enriches learning experiences by

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DOI: https://doi.org/10.64388/IREV9I7-1713555

providing actionable insights into student performance. In the contemporary educational landscape, students increasingly rely on digital tools such as tablets and laptops, with advanced e-learning applications allowing them to learn at their own pace and enjoy consistent learning experiences across physical and virtual spaces (El-Sabagh, 2021).

Methodology

This study adopted a descriptive survey research design to investigate undergraduates' awareness, utilisation, and attitude towards the use of the Internet of Things (IoT) for interactive learning at the university in Ilorin, Kwara State, Nigeria. The population comprised all undergraduates of the university in Ilorin, from which a sample of 120 students was selected using a simple random sampling technique from the Faculty of Engineering and the Faculty of Computer and Information Sciences. Data were collected using a structured questionnaire designed by the researcher, which consisted of four sections covering demographic information, awareness of IoT for learning, utilisation of IoT for learning, and attitude towards the use of IoT for learning. The instrument was validated by the project supervisor and three lecturers from the Department of Educational Technology, while its reliability was established using Cronbach's Alpha. The questionnaire was administered physically, retrieved immediately after completion, and accompanied by informed consent to ensure confidentiality and anonymity of respondents. Data collected were analysed using frequency counts, percentages, and mean scores, while the formulated hypotheses were tested at the 0.05 level of significance using SPSS statistical software. The chapter presented the demographic characteristics of the respondents, provided answers to the research questions, tested the hypotheses, and summarised the key findings of the study.

Demographic Information of the Respondents

Table 1: Distribution of the Participants Based on Gender

Gender	Frequency	Percent
Male	83	70.3389831
Female	35	29.6610169
Total	118	100

Table 1, shows the participants' distribution based on gender. The table shows that the majority of the respondents, 70.33%, are male, while only 29.67% of the participants are female. Figure 1 further presents their distribution in pie chart.

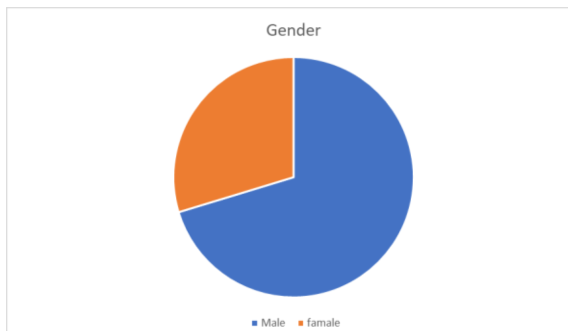

Figure 1: Distribution of the Participants Based on Gender

Table 2: Distribution of the Participants Based on Faculty

Faculty	Frequency	Percent
Engineering	58	49.2
Communication and Information Science	60	50.8
Total	118	100

Table 2 reveals that 49.15% of the respondents were from the faculty of Engineering, while 50.85% of the respondents were from the faculty of Communication and Information Science. This implies that participants

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DOI: https://doi.org/10.64388/IREV9I7-1713555

are equally represented in the study. Figure 2 further presents their distribution in a pie chart.

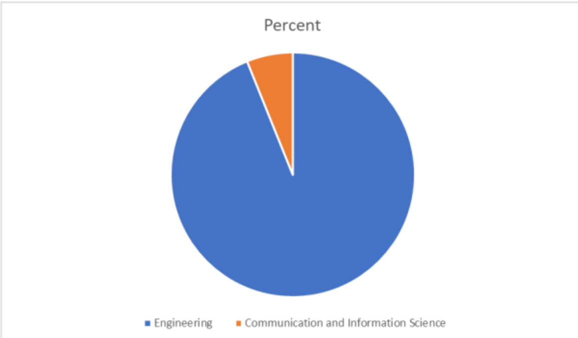

Figure 2: Distribution of the Participants Based on Faculty

Research Question One: What is the level of awareness of the Internet of Things (IoT) for interactive learning among undergraduates at the university in Ilorin?

Table 3: Frequency and Percentage of the level of Awareness of the Internet of Things for interactive learning among Undergraduates at University in Ilorin

S/N	Items	Aware	Not Aware
1.	Interactive Clickers and Audience Response Systems	74(62.7)	44(37.3)
2	Cloud Computing	93(78.8)	25(21.2)
3	Learning Management System (LMS)	85(72.0)	33(28.0)
4	Virtual Reality (VR) Tools	88(74.6)	30(25.4)
5	Augmented Reality (AR) Tools	58(49.2)	60(50.8)
6	Sensors and Devices	104 (88.1)	14 (11.9)
	Percentage (%)	502(70.9)	206(29.1)

Key: A = Aware, NA = *Not* Aware

Decision Value (%): Aware = 50 – 100%, *Not* Aware = 1 - 49.9%

Table 3 shows the level of awareness of the Internet of things for interactive learning among undergraduates of University in Ilorin. It was revealed that 70.9% of the sampled Universities students indicated that they are aware of the highlighted tools of internet of things for interactive learning while 29.1% of the sampled students indicated that they are not aware of the tools for interactive learning. However, based on the value of the overall percentage of aware (70.9% out of 100% obtainable) which falls within the decision value for *Aware*, it can be deduced that undergraduates in the selected faculties of the university are aware of tools of the Internet of Things for interactive learning.

Research Question Two: What is the level of utilization of the internet of things (IoT) for interactive learning among undergraduates at the University in Ilorin?

Table 4: Frequency and percentage of the level of utilization of the Internet of things (IoT) for interactive learning among undergraduates at University in Ilorin

S/N	Item	SA	A	D	SD	Mean
1.	Using internet of things devices encourages critical thinking	45	50	18	5	3.14
2.	Using devices and sensors can facilitate remote learning to conduct experiments and data collection	65	45	7	1	3.47
3.	Using internet of things increased student engagement	61	50	7	0	3.45
4.	Using Internet of Things engages collaborative learning opportunities	64	42	10	2	3.42
5.	Using Internet improved understanding of complex concepts	69	43	6	0	3.53
6.	Learning Management System platforms enable the creation of quizzes and assessments to IoT topics	59	50	8	1	3.41
7.	Cloud-based IoT simulators allow students to experiment with virtual IoT devices and networks	52	57	8	1	3.35
8.	Virtual Reality can transform data visualization into 3D, immersive experiences	48	55	14	1	3.27
9.	Augmented reality can simulate real-world IoT scenarios for training purposes	48	49	18	3	3.2
10.	Using Internet of Things encourage real-time feedback and assessment	47	53	16	2	3.22
	Grand Mean (X)					3.35

Key: SD = Strongly Disagree, D= Disagree, A = Agree, SA = Strongly Agree

Decision Value: *Not Utilize* = 0.00-2.44, *Utilize* = 2.45-4.00

Table 4 shows the level of utilisation of the Internet of Things (IoT) for interactive learning among undergraduates at the University in Ilorin. It was revealed from the table that all the items received a mean score within the benchmark of 2.44 - 4, designated for *Utilise,* with "Using Internet improved understanding of complex concepts" having the highest score of $\bar{x}$ = 3.53 and "Using internet of things devices encourages critical thinking" with the lowest score of $\bar{x}$ = 3.14. Therefore, based on the value of the Grand Mean (3.35 out of 4.00 obtainable), which falls within the decision value for *Utilise,* it can be inferred that Internet of Things is utilised for interactive learning among Undergraduates in selected faculty.

Research Question Three: What is the attitude of the undergraduate students of the University in Ilorin toward Internet of Things (IoT) for interactive learning?

Table 5: Frequency and Mean Score of the attitude of the undergraduate students of the University in Ilorin toward internet of things for interactive learning

S/N	Item	SA	A	D	SD	Mean
1	Using internet of things can make learning easier	47	49	4	18	3.05
2	Using virtual reality tools can improve my academic performance	27	61	18	11	2.88
3	Internet of Things help me in keeping good records of my lectures	35	51	18	14	2.90
4	Privacy concerns make me hesitant about using IoT in learning	21	51	33	13	2.67
5	Misconceptions about learning concepts can easily be corrected using the Internet of Things	31	56	21	10	2.91
6	Internet of things make learning accessible and adaptive	43	55	10	10	3.11
7	Internet of things should be highly encouraged and introduced to the academic arenas	56	41	7	14	3.17
	Grand Mean (X)					2.96

Key: SD = Strongly Disagree, D= Disagree, A = Agree, SA = Strongly Agree

Decision Value: *Negative* = 0.00-2.44, *Positive* = 2.45-4.00

Table 5 shows the attitude of undergraduates toward the the Internet of things (IoT) for interactive learning in University in Ilorin. It was revealed from the table that all the items received mean scores within the benchmark of 2.44 - 4 designated as *Positive* with “Internet of things should be highly encouraged and introduced to the academic arenas” having the highest score of $\bar{x}$ = 3.17 and “Privacy concerns make me hesitant about using IoT in learning” with the lowest score of $\bar{x}$ = 2.67. Therefore, based on the value of the Grand Mean (2.96 out of 4.00 obtainable) which falls within the decision value for *Positive,* it can be inferred that students from both faculties examined have positive attitude towards the Internet of things for interactive learning.

Hypotheses Testing

Hypothesis One: There is no significant difference in the awareness level of IoTs for interactive learning among the undergraduates based on gender

Table 6: t-test showing a Significant Difference in the awareness level of IoTs for interactive learning among the undergraduates based on gender

Gender	N	X	SD	Df	T	Sig.(2-tailed)	Decision
Male	83	1.93	0.23				
				116	1.006	.316	Not Rejected
Female	35	1.88	0.32				
Total	118						

Table 6 indicates that the degree of freedom is 116, t= 1.006, p= .316 the null hypothesis was not rejected. This was as a result of the t-value of 1.006, resulting in a .316 significance value which was greater than 0.05 alpha value. Thus, the stated null hypothesis was established: There was no significant difference in the awareness level of IoTs for interactive learning among the undergraduates based on gender. Therefore, the gender of respondents does not influence the awareness level of IoTs.

Hypothesis Two: There is no significant difference in the awareness level of IoTs for interactive learning among the undergraduates based on the faculty

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DOI: https://doi.org/10.64388/IREV9I7-1713555

Table 7: t-test showing a Significant Difference in the awareness level of IoTs for interactive learning among the undergraduates based on faculty

Gender	N	X	SD	Df	T	Sig.(2-tailed)	Decision
Engineering	58	1.87	0.32				
				116	-1.79	.075	Not Rejected
CIS	60	1.96	0.18				
Total	118						

Table 7 indicates that the degree of freedom is 116, t= -1.79, and p= .075; the null hypothesis was not rejected. The significance value of 0.075 was greater than 0.05 alpha value; therefore, the stated null hypothesis was established: There was no significant difference in the awareness level of IoTs for interactive learning among the undergraduates based on faculty. Therefore, the faculty of respondents does not influence the awareness level of IoTs.

Hypothesis Three: There is no significant difference in the utilisation level of IoTs for interactive learning among the undergraduates based on gender

Table 8: t-test showing a Significant Difference in the utilization level of IoTs for interactive learning among the undergraduates based on gender

Gender	N	X	SD	Df	T	Sig.(2-tailed)	Decision
Male	83	3.40	0.56				
				116	1.086	.280	Not Rejected
Female	35	3.28	0.57				
Total	118						

Table 8 indicates that the degree of freedom is 116, t = 1.086, and p = .280; the null hypothesis was not rejected. A significance value of 0.316 which was greater than 0.05 alpha value, thus, the stated null hypothesis that there was no significant difference in the utilization level of IoTs for interactive learning among the undergraduates based on gender was proven. Therefore, irrespective of gender, the level of utilization of the Internet of Things is equal.

Hypothesis four: There is no significant difference in the utilisation level of IoTs for interactive learning among the undergraduates based on the faculty

Table 9: t-test showing a Significant Difference in the utilisation level of IoTs for interactive learning among the undergraduates based on the faculty

Gender	N	X	SD	Df	t	Sig.(2-tailed)	Decision
Engineering	58	3.32	0.60				
				116	-0.85	.396	Not Rejected
CIS	60	34.1	0.53				
Total	118						

Table 9 shows that the degree of freedom is 116, t= -0.85, and p= .396; the null hypothesis was not rejected. The significance value of 0.396 was greater than the 0.05 alpha value; therefore, the stated null hypothesis was established: There was no significant difference in the utilization level of IoTs for interactive learning among the undergraduates based on faculty. Therefore, the faculty of respondents does not influence the utilization level of IoTs.

Summary of Findings

The findings of this study based on the formulated research questions and the hypotheses were summarized as follows:

1. Undergraduates in selected faculties of University in Ilorin, Kwara State are well aware of the tools of internet of things.
2. The level of utilization of Internet of things (IoTs) for interactive learning among Undergraduates in the selected faculties of University in Ilorin, Kwara State is high.
3. The attitude of Undergraduates in the selected faculties towards the adoption of internet of things for interactive learning are positive.
4. There was no significant difference in the awareness level of IoTs for interactive learning among the undergraduates based on gender.
5. There was no significant difference in the awareness level of IoTs for interactive learning among the undergraduates based on faculty.
6. There was no significant difference in the utilization level of IoTs for interactive learning among the undergraduates based on gender.
7. There was no significant difference in the utilization level of IoTs for interactive learning among the undergraduates based on faculty

Discussion of Findings

The findings of this study are discussed in relation to the reviewed literature on the Internet of Things (IoT) and its applications in education. The discussion is structured around the major outcomes of the study, aligning them with existing theoretical and empirical perspectives from prior research. The study revealed that undergraduates in the selected faculties of the University in Ilorin, Kwara State, are well aware of IoT tools. This high level of awareness corroborates Jameel et al. (2024), who observed that IoT has become a global technological trend with growing visibility across various sectors, including education. The increased awareness among students may be attributed to the proliferation of smart devices, digital learning platforms, and ubiquitous Internet access, all of which have facilitated familiarity with IoT-based applications in everyday life. As highlighted by Alaba (2024) and Mykola et al. (2023), the diffusion of IoT technologies has permeated modern society, influencing how individuals interact, learn, and make decisions.

Furthermore, the awareness level observed among students aligns with the assertion of Vermesan et al. (2022) that IoT technologies are now ubiquitous and accessible, bridging the physical sensors. The exposure of undergraduates to these technologies within academic and social contexts likely enhances their understanding and appreciation of IoT tools for interactive learning. The study found a high level of IoT utilisation for interactive learning among undergraduates. This finding aligns with the work of Matthew et al. (2021), who stated that IoT integration in higher education fosters innovation in instructional delivery, enhances real-time interaction, and streamlines institutional management. The result also supports Ane et al. (2020), who argued that IoT technologies directly influence teaching and learning processes by promoting individualised and measurable learning experiences. IoT enables real-time feedback and interconnectivity between students and instructors, which supports active learning and continuous assessment. According to El-Sabagh (2021), digital tools such as IoT-based learning platforms enhance learning flexibility, allowing students to learn at their own pace while maintaining engagement and consistency across physical and virtual spaces. Therefore, the high utilisation level recorded in this study may reflect students' adaptation to these evolving technologies as part of their academic routines.

Additionally, IoT supports the integration of multiple e-learning systems and interactive applications, such as smart boards, learning analytics, and real-time communication platforms, which enhance instructional quality and efficiency. The results thus reinforce the argument of Mahmood et al. (2020) that IoT facilitates data-driven decision-making and continuous monitoring of learners' progress, creating an enabling environment for personalised education. The study also established that undergraduates hold positive attitudes toward adopting IoT for interactive learning. This finding resonates with the perspectives of Dipali et al. (2017) and Singh (2023), who noted that IoT technologies are often perceived as enablers of convenience, efficiency, and innovation. The positive disposition of students may stem from their perception of IoT as a tool that simplifies academic tasks, promotes collaboration, and enriches learning experiences.The literature underscores that IoT adoption in education not only enhances learning outcomes but also promotes autonomy, motivation, and creativity among students (Li et al., 2022). By enabling interactive and immersive experiences, IoT technologies align with contemporary pedagogical approaches that emphasise active participation and learner engagement. This finding further confirms Maclean's (2020) assertion that human-machine interactions, though complex, can foster empowerment and new forms of digital literacy when appropriately managed.

The study found no significant difference in both awareness and utilisation of IoT for interactive learning based on gender. This finding aligns with the assertion of Mahbub (2020) that access to IoT technologies has become increasingly democratised, transcending gender boundaries. In contemporary higher education, both male and female students are equally exposed to digital learning environments and devices, thereby minimising gender-based disparities in technology awareness and use. The absence of significant gender differences also supports the findings of Mazhar et al. (2022), who reported that the integration of IoT in educational contexts fosters inclusivity by providing equal access to information and learning tools. This implies that IoT-based learning platforms, by design, encourage equitable participation, thus reducing the digital divide traditionally associated with gender in technology adoption. Similarly, no significant difference was found in IoT awareness and utilisation among undergraduates across different faculties. This result may be attributed to the pervasive integration of digital technologies across disciplines, as noted by Waleed (2024). The growing emphasis on digital literacy and the adoption of technology-supported pedagogies across faculties contribute to a relatively uniform exposure to IoT tools. The finding also reinforces the argument of Ovidiu et al. (2022) that IoT's influence spans various academic domains through its middleware, sensor, and semantic models, enabling faculty-wide implementation of connected systems. Therefore, irrespective of academic discipline, students engage with IoT-enabled learning environments through similar technological infrastructures, leading to comparable awareness and utilisation patterns.

Implication of the Study

The results of this study have broad implications that affect many different areas of the educational environment. Firstly, in educational settings, institutions should further enhance the integration of the Internet of Things (IoTs) into education for proper classroom learning. Moreover, the study highlights an opportunity for students to undergo professional development, acquiring the skills necessary to effectively introduce IoTs into their learning methods. Additionally, the positive usage patterns observed among students indicate that educators can experiment with diverse pedagogical approaches, leveraging IoTs holistic and experiential nature to enhance learning. Encouraging students to actively engage with IoTs tools and participate in training could significantly improve their thought and retention of course materials.

Conclusion

This study concluded that undergraduates in the selected faculties of the University in Ilorin, Kwara State, possess a high level of awareness and actively utilise Internet of Things (IoT) tools for interactive learning. Their positive attitudes toward IoT adoption reflect a strong readiness to embrace emerging technologies that enhance engagement, efficiency, and innovation in the learning process. The absence of significant differences in awareness and utilisation levels across gender and faculty indicates that IoT adoption in the university is inclusive and evenly distributed among students, suggesting equitable access to technological resources and learning opportunities.

Limitations of the Study

The following limitations were observed during the course of this study:

1. The population of this study was limited to only two faculties in the University in Ilorin; the findings may not be generalised to all Undergraduates in the University and Nigeria at large.
2. The study was designed to the level of awareness, utilisation and attitude of Undergraduates towards some selected tools of IoTs for interactive learning. Thus, more emerging IoTs tools could be introduced for further research.
3. The moderating variables in this study are gender and faculty, but they did not extend to the academic level and perhaps the age range of the students.

Recommendations

Based on the findings and conclusions, recommendations were made:

1. The government is urged to do more to promote IoT development and adoption by being a lead adopter of the IoT in education ministries/agencies.
2. Government and institutional authorities should provide IoT devices to enable the students to access the internet easily.
3. Government and schools should provide an efficient power supply for teachers and students in their schools to make use of available IoT devices effectively.
4. Authorities should provide an enabling environment and strict adherence to best practices toward IoT in technical colleges for effective utilisation.
5. Institutions can facilitate collaborations between educational researchers, IoT developers, and students to explore innovative applications of IoT technology.

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