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RESEARCH ARTICLE

Enhanced Technology Acceptance Model for the Adoption of IoT Devices among University Students

Ting Tin Tin[1], Teh Han Yang[2], Jeang Shao Eng[3], Eui Chen Hoe[4], Edwin Chong Hong Yun[5], Wan Nor Al-Ashekin Wan Husin[6], Ali Aitizaz[7], Lee Kuok Tiung[8*], Sunday A. Afolalu[9], Umar Farooq Khattak[10]

[1,6,9]Faculty of Data Science and Information Technology, INTI International University, Nilai 71800, Malaysia
[2-5]Faculty of Computing and Information Technology, Tunku Abdul Rahman University of Management and Technology, Kuala Lumpur, Malaysia
[7]School of technology, Asia Pacific University, Malaysia
[8]Faculty of Social Science and Humanities, 88400 Kota Kinabalu, Universiti Malaysia Sabah, Malaysia
[9]Department of Mechanical and Mechatronics Engineering, Afe Babalola University, Ado-Ekiti, 360101, Nigeria
[9]Department of Mechanical Engineering Science, University of Johannesburg, 2092, South Africa
[10]School of IT, Unitar International University, Malaysia

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***Corresponding Author:**

tintin.ting@newinti.edu.my

ABSTRACT

The enhanced technology acceptance model (ETAM) for the adoption of IoT Device Adoption among university students builds upon the Traditional Technology Acceptance Model (TAM) by integrating additional factors such as perceived usefulness, perceived ease of use, perceived security awareness, and perceived satisfaction to provide a comprehensive understanding of students' acceptance and usage behaviours toward IoT devices in educational settings. Enhanced Technology Acceptance Model (ETAM) for IoT devices adoption among university students could be the potential challenge of accurately measuring and quantifying perceived satisfaction and usage toward IoT Devices, which are subjective factors that can vary greatly among individuals and contexts. The purpose of this study was to determine the acceptance by university students of the use of IoT devices. This study analyses the impacts that influence the acceptance of usage toward IoT devices. This research includes reliability analysis, demographic, Pearson correlation, and mediation analysis. The results show a 183-sample size, and 7 variables were modelled and analysed using SPSS and process macro. The main outcome of the contribution of the article could be the development of iot devices that specifically address the factors influencing IoT device adoption of ioT devices among teenagers in Malaysia. These enhanced IoT devices would provide a better understanding of the acceptance of technology within this demographic, providing valuable insights for policymakers, educators, industry professionals, and researchers seeking to promote the responsible and effective adoption of IoT devices among Malaysian teenagers. This study is likely to propose enhancements or modifications to the traditional TAM framework to better fit the context of the adoption of IoT devices among teenagers.

INTRODUCTION

The term "Internet of Things" (IoT) refers to a network of physical items, from cars to buildings, integrated with electronics, software, and sensors to facilitate data collection and sharing (Pradyumna et al., 2018). In 1999, Kevin Ashton introduced the concept at Proctor & Gamble, emphasizing the role of RFID technology in supply chain management (Mouha, 2021). Today, IoT

systems utilize cutting-edge technologies such as wireless sensor networks (WSNs) and RFID, enabling machines to exchange data and make informed decisions (Balaji et al., 2019). IoT platforms play a crucial role in supporting specialized applications by providing services such as endpoint administration, analytics, security, and more (Mineraud et al., 2016). However, as technology evolves and new IoT devices emerge, the challenge for businesses and organizations lies in selecting the most suitable platform to meet present and future demands (Hejazi et al., 2018;Guth et al., 2016). This technology shift requires navigating unfamiliar IoT infrastructure and platform options, highlighting the importance of informed decision-making in adapting to the changing landscape. The The Technology Acceptance Model (TAM) is a widely adopted analytical model to study people's use of IoT technology (Agustina et al., 2021). The Technology Acceptance Model (TAM) is a well-known model that measures how well technologies are received by users. The Technology Acceptance Model (TAM) determines the ways that individuals get technology within a mental model and has been used to analyse the adoption of a range of technologies in various areas (Masadeh et al., 2023). Technology Acceptance Model (TAM) is a model to look at the acceptance of information technology. There are four main factors to consider which are perceived awareness of security, perceived ease of use, perceived satisfaction, and perceived usefulness (Situmorang, 2024).This research thoroughly looks at the Technology Acceptance Model (TAM) to determine the intention of using any IoT device or application by IoT technology (Yap et al., 2023).

Problem Statement

All things considered, the Internet of Things is a technological advancement that combines a wide range of smart devices, frameworks, and smart systems. Furthermore, it leverages the advantages of quantum and nanotechnology to achieve previously unthinkable levels of storage, sensing, and computing speed (Khanna and Kaur, 2020). Although the Internet of Things devices are highly intriguing and offer technology for smart everything, there are significant problems in using the concept due to the high implementation costs. For example, the power supply, security and connectivity lead to high implementation costs (Thouti et al., 2022). The acceptance of technology is vital to consider in the adoption of new technology. Research indicates that identifying key factors of IoT acceptance is essential to ensure the adoption and successful deployment of IoT products and services for business use (McKenney, 2021). IoT products and services become the main problem for usage towards ioT devices.

A significant part of the development of the Internet of Things is also relied upon to happen in the assembly division. Only a minority of firms have Internet of Things initiatives, and only a lesser percentage of them have effectively incorporated Internet of Things frameworks (Olushola, 2019). However, before the IoT vision becomes a reality, several difficult challenges still need to be resolved, and social and technological knots need to be connected. The main challenges are how to ensure user privacy, security and trust while providing full interoperability between networked devices and giving them a high degree of intelligence by allowing adoption and autonomous behaviour (Rosas et al., 2017).

2.0 LITERATURE REVIEW

Perceived usefulness and its impacts on use of IoT Devices

In the TAM model technology acceptance model, perceived usefulness is an important variable that allows people to accept information technology (Kang and Hwang, 2022**)**. Perceived usefulness also assesses the characteristics that encourage people to use IoT devices (Alqarni et al., 2024; Gül et al., 2024). With the impacts on the usage of Iot devices, life can become easier and more convenient for people. For example: remote control appliances, appliances can be switched off and on automatically to avoid accidents and save energy (Shendge, 2021; Waheed et al., 2010).

Next, we seek to determine what influences perceived usefulness and its impacts on IoT devices. Individual's personal characteristics or traits could influence their perception of technology usefulness on usage of IOT devices (McKenney, 2021; Jam et al., 2011). In the context of usage of IoT devices, we say that perceived usefulness is personal and could be determined by personality. In

recent years, many information system studies have incorporated personality traits in attempts to explain user acceptance which has also been demonstrated by numerous studies (Chahal and Rani, 2022). The reason to examine personality traits in the study of IoT device usage is because the basic concept underlying the model places a significant focus on individual's reactions in which personality traits are expected to play an important role in influencing the decision of usage on IoT device usage. The Theory of Reasoned Action as the basis for the use of Iot devices also explicitly incorporated personality traits as an external variable that affects an individual's adoption of technology (Roh et al., 2023). Based on those propositions, it is logical to assume that the role of personality here is influencing an individual's towards usage of IoT devices and perceived usefulness. From the perspective of traits to our knowledge, the best conceptualization of personality is the five-factor model of personality (Wang and Li, 2023), also called the "Big Five Model." Goldberg designed it in 1982, which later became the basis of proposing that an individual's characteristics can be described regarding their scores on five personality domains including openness, conscientiousness, agreeableness, extraversion, and neuroticism (Khoo et al., 2023). Some research was compiled that studies the impact of perceived usefulness of IoT devices (Opoku, 2020), and among these studies, there was a various degree of prediction from each variable toward perceived usefulness of many kinds of IoT devices and its impacts on usage of IoT devices.

Perceived ease of use and its impacts on the use of IoT Devices

Perceived ease of use refers to how easily a person believes they can understand a system's functionality. In today's quest for minimizing workflows and enhancing convenience, integrating IoT into daily lives provides features like voice commands and motion detection, simplifying device activation and deactivation (Anuradha et al., 2023). IoT plays an important role in increasing current living standards, offering unprecedented ease and comfort. Among its applications, smart home technology, a subset of IoT, not only promotes autonomy but also improves the quality of life for individuals, regardless of special needs, by helping in their daily tasks (Maswadi et al., 2022). Furthermore, IoT-based applications automatically update sensor data to the Internet, facilitating seamless device-to-device communication without human intervention (Faber et al., 2020). Furthermore, people with special needs make use of smart home technology to improve their quality of life, promote independence, and actively participate in daily routines (Ulloa et al., 2021 cited in Turki et al., 2024).

TAM argues that perceived ease of use is one of the key determinants of user intention to use technology (Al-Qaysi et al., 2020). A study by (Tsourela and Nerantzaki, 2020), which found that the relationship between trust and perceived ease of use (PEOU) is stronger than that of social influence in the context of IoT adoption. The research suggests that consumer trust significantly influences perceived ease of use, particularly in online environments where users need assurance of privacy and security. This trust encourages users to explore IoT products freely, contributing to their perception of ease of use. Overall, the findings highlight the importance of trust in facilitating the adoption and usage of IoT technologies. In addition to that, there are two studies that highlight the importance of perceived ease of use in driving the adoption and usage of IoT technology. (Yap and Kamuruddin, 2023) found a strong positive relationship between perceived ease of use and intention to use IoT, while (Parves et al., 2022) similarly showed a significant positive relationship between perceived ease of use and intention to use robot technology. These findings highlight the crucial role of user-friendly interfaces and systems in encouraging widespread adoption of IoT devices. In our own study, which focuses on participation intention and loyalty intention, we predict similar consequences for the impact of perceived ease of use on user behaviour and adoption of IoT technology.

Perception of satisfaction and its impacts on the use of IoT devices

Perception of satisfaction refers to the user's experience with the IoT device with regard to the overall user experience. IoT devices collect the daily routine of the user to improve the satisfaction of the user in the future (Nitin, 2023). According to research of (Orlov et al., 2024), a well-designed training program can increase the satisfaction of the IoT device by correctly identifying the features

or functions that is needed by the user by giving guidelines and instructions on how to use it. Therefore, the advantages of implementing IoT technology are mainly focused on enhancing the overall customer experience, which plays a significant role in boosting customer satisfaction levels (Ahmed et al., 2022). Furthermore, when IoT devices are applied in the workplace, employees can be focused on the satisfaction that comes with completing their work as well. Individuals who feel meaningful and happy at work are more likely to be efficient and flexible with the use of IoT devices. By creating a culture that encourages self-motivation, increased job satisfaction with better teamwork and overall organizational effectiveness (Türkeş et al., 2020).

The consideration of satisfaction is the operational speed which a system operates which plays a significant role in determining how satisfied users feel when they interact with it, and faster and more efficient systems affect the overall satisfaction experience with system usage (Mostafa et al., 2020). The user experience with the information provided by the system greatly impacts how useful it is. As satisfied with the overall quality of the information, satisfaction with the system with experience and enhanced satisfaction makes the system more approachable and user friendly. (Li et al., 2020). IoT indeed brings about a remarkable transformation across multiple domains, its aim being to optimize operations, save time, and minimize efforts. By connecting various devices and systems, IoT enables efficient data collection, analysis, and automation, ultimately leading to increased productivity and better resource management (Hussein et al., 2018). Besides that, the IoT revolution will lead to time and effort savings, as well as making tasks easier to do and enhancing process speed. This advance can greatly benefit industries, households, and individuals, making their lives more convenient and productive. (Nitin, 2023). The adaptability, affordability, and security of IoT play an important role in data collection and transfer to influence decision making processes.IoT deployment contributes to a more efficient and time-saving work environment, which benefits both the company and its employees.(Mostafa et al., 2019). Moreover, it is essential to prioritize to guarantee that users feel confident and secure, the platform must implement strong security measures and communicate openly about them. By demonstrating a strong commitment to user safety, the wearable platform can build confidence and inspire widespread adoption (Pal et al., 2019).

Perceived Security Awareness and its impacts on usage of IoT Devices

An assertion will be made in my literature review that as users become more aware of security issues related to the IoT, the adoption of IoT devices will be impacted positively. The awareness of user security of IoT usage is proliferating. So, what is security awareness? The level of understanding and familiarity with the emerging security and privacy risks associated with IoT devices that they may face on a daily and routine basis is known as IoT security awareness (Koohang et al., 2022). The importance of security awareness in the context of the Internet of Things (IoT) is underscored by various privacy concerns associated with user data (Wang et al., 2019). These concerns encompass different dimensions, including identity privacy, data privacy, attribute privacy, and task privacy. There is now more pressure than ever to solve privacy and security awareness in order to prevent people from choosing not to give up using their devices (Karwatzki et al., 2017).

It has emphasized users' desire to understand the policies governing their data management within IoT systems and to be informed about data access, reflecting a broader need for user awareness and empowerment. This aligns with the subsequent section's focus on analysing key security requirements, such as confidentiality, integrity, and availability of information and information resources (assets) within IoT environments (Maleh et al., 2021). The constant transfer and sharing of data in IoT underscore the importance of authentication, authorization, access control, and non-repudiation to ensure secure communication. With secure communication between users and IoT devices, user understanding will ultimately and enable informed decision-making regarding data management within IoT devices (Zhang et al., 2024). If users are not aware of or do not know how to adhere to a security policy, even the finest one in the world will have no effect. The process of educating users on policies and how to utilize them effectively is known as SETA, Security Education, Training, and Awareness (Marvik and Bakir, 2023). Because many types of IoT devices lack user interfaces, consumers will need even more assistance in using devices appropriately. With a SETA

program, users can avoid being the weakest link by learning about dangers. They may increase their interest towards the use of IoT devices.

Despite the growing interest among IoT users in adopting IoT devices, wearable technology and smart houses stand out as prime examples of how the explosive expansion of the Internet of Things (IoT) has significantly transformed various aspects of human life. However, ensuring user privacy and security remains a significant challenge. The unique characteristics of IoT systems, such as scalability, dynamic adaptability, imperfect connectivity, and resource constraints, further complicate the landscape. Innovative security and privacy solutions are required due to these special traits. In IoT-based systems, specific risks associated with RFID, wireless sensor networks (WSNs), and mobile delay-tolerant networks (MDTNs) have been identified (Badr et al., 2021). IoT security awareness is greatly affected by users' knowledge of ransomware attacks, data breaches, device vulnerabilities, and unauthorized access to personal information. Interestingly, despite feeling secure using IoT devices, consumers often forget to verify their security settings (Nemec Zlatolas et al., 2022). Researchers have designed robust methodologies to quantify the impact of security awareness on IoT device adoption. By examining user behaviour, preferences, and decision-making processes, they shed light on the intricate relationship between awareness and adoption. The adoption curve for IoT devices is influenced by various factors, including perceived security risks. As people become more conscious of potential threats, their willingness to embrace IoT technologies evolves. Consumers are increasingly aware of the risks associated with IoT devices. They recognize that convenience should not come at the expense of security and privacy. The study reinforces the idea that users are unwilling to compromise their safety for the sake of convenience. Balance of usability with robust security measures is the key to long-term adoption (Aziz et al., 2023). Table 1 summarizes the literature study of the covariates of the use of IoT devices with related conceptual frameworks constructed for this research (Figure 1).

Table 1. Covariates of the Use of IoT Devices the Previous Studies

Covariate	Detail Variables	Previous studies
Perceived Usefulness	TAM model	Kang and Hwang, 2022
	Characteristics	Alqarni et al., 2024
	Impacts of Use of IoT Devices	Shendge, 2021
	Personality traits	McKenney, 2021; Chahal and Rani, 2022; Roh et al., 2023
	Theory of Reasoned Action	Wang and Li, 2023
	Big Five Model	Khoo et al., 2023
	Previous Studies	Opoku, 2020
Perceived Ease of Use	Integration of IoT into daily lives	Anuradha et al., 2023
	Enhance quality of life through smart home technology	Maswadi et al., 2022
	Seamless device-to-device communication	Faber et al., 2020
	The use of smart home technology by individuals with special needs	Ulloa et al., 2021 cited in Turki et al., 2024
	Determinants of the user's intention to use technology according to TAM	Al-Qaysi et al., 2020
	Relationship between trust and perceived ease of use	Tsourela and Nerantzaki, 2020
	Relationship between perceived ease of use and intention to use IoT	Yap and Kamuruddin, 2023; Parves et al., 2022
Perceived Satisfaction	Loyalty through AI, IoT, and Big Data	Nitin, 2023
	User experience	Orlov et al., 2024
	Impact of Implementing the IoT	Ahmed, 2022
	Motivation	Türkeş et al., 2020
	Warehouse management system using the IoT	Mostafa et al., 2020
	Delay-sensitive IoT Application	Li et al., 2020
	Prospect of IoT	Hussein et al., 2020
	Supply Chains	Mostafa et al., 2019

	Trust and the continuance intention	Pal et al., 2020
Perceived Security Awareness	Attachment styles, self-confidence, problem-solving skills, communication behaviors, conflict negotiation strategies	Alex Koohang et al., 2022; Wang et al., 2020; Karwatzki et al., 2017; Maleh et al., 2021; Zhang et al., 2024; Niemimaa, 2023; Youakim Badr et al., 2021; Zlatolas et al., 2022

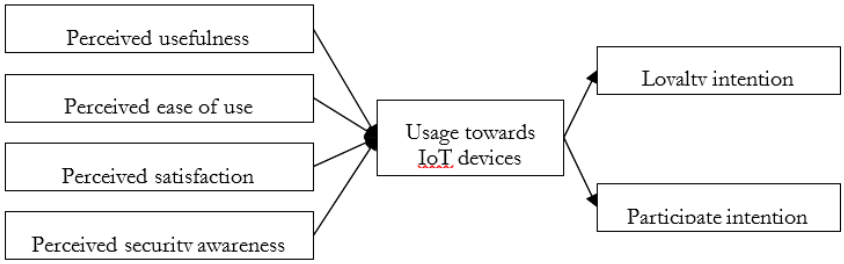

Figure 1. Conceptual framework of the research study.

3.0 RESEARCH METHODOLOGY

This study is carried out on a specific population of university students from Tunku Abdul Rahman University of Management and Technology (TAR UMT Kuala Lumpur Campus). This population is selected based on a convenient sampling method and simple random sampling since the researchers are studying within the campus, which facilitates data collection. The main reason for the selected population is that teenagers meet the extensive usage of IoT devices among university students in TAR UMT. Facebook, Instagram, and WhatsApp are used to distribute the Google survey form through a link and QR code. A total of 183 respondents participated in this survey.

There are seven sections designed to adopt questionnaire items from previous research (Appendix A): section 1–perceived usefulness(Lu, 1970); section 2 - perceived ease of use (Yap and Nor, 2023; Wu and Wang, 2005; Gong et al., 2004); section 3 - perceived satisfaction (Shin, 2017); section 4 - perceived security awareness (Muniandy et al., 2017); section 5 - use of Iot devices (Ting et al., 2023); section 6 - loyalty intention and section 7–participate intention (Wibowo et al., 2021). The dataset will be analysed using SPSS and process macro tools. The Pearson correlation method will be tested with H1-6 while H7-14 will use the mediating analysis.

4.0 RESULTS

Reliability analysis

The Cronbach alpha reliability coefficient was used to assess the reliability of the pilot test results in Table 2. The alpha correlation coefficients for each aspect of the questionnaire ranged from 0.848 to 0.921. Therefore, all coefficients were significant, indicating that the reliability of the questionnaire falls into the category of acceptable to good.

Table 2. Reliability level of Questionnaire Items

Questionnaire items sections	Cronbach alpha based on standardized items	Number of items
Perceived Usefulness	0.903	4
Perceived Ease of Use	0.893	6
Perceived Satisfaction	0.848	6
Perceived Security Awareness	0.920	15
Usage of IOT Devices	0.896	9
Loyalty Intention	0.894	5
Participate Intention	0.921	5
Total	0.910	50

Demographic

A total of 183 valid responses in this study with their demographics are shown in Table 3. There is a proportion of gender between the total valid data, which shows that 83.7% of the responses emanated from men, while 15.8% of the responses were from females. Furthermore, most respondents of age are from 20-22 (83.6%). 99.5% of the respondents were from the university.

Table 3. Demographics Information of Participants

Characteristics		Frequency	Percentage
Age	18	1	.5
	19	3	1.6
	20	22	12.0
	21	114	62.3
	22	17	9.3
	23	7	3.8
	24	4	2.2
	26	7	3.8
	27	1	.5
	30	6	3.3
	32	1	.5
Gender	Female	29	15.8
	Male	154	83.7

Pearson correlation (H1 - H6)

Table 4 shows the correlation between independent variables (IV) and dependent variables (DVs). Perceived usefulness, ease of use, satisfaction and security awareness all show strong positive correlations with the usage of IoT devices, with Pearson's correlation coefficients ranging from 0.433 to 0.718 accepted. Therefore, the relationship between perceived usefulness, ease of use, satisfaction, security awareness, and usage towards IoT devices is supported. Additionally, the analysis shows that the extent of device usage significantly predicts both loyalty intention and participation intention, with correlation coefficients of 0.650 and 0.540, respectively. Thus, the relationship between usage towards IoT devices and loyalty intention, as well as participation intention, are also supported.

Table 4. Correlation of Independent Variable and Dependent Variable

Independent Variable	Dependent Variable	Pearson's Correlation
Perceived Usefulness	Usage of IoT Devices	0.433**
Perceived Ease of Use	Usage of IoT Devices	0.600**
Perceived Satisfaction	Usage of IoT Devices	0.442**
Perceived Security Awareness	Usage of IoT Devices	0.718**
Usage of IoT Devices	Loyalty Intention	0.650**
Usage of IoT Devices	Participate Intention	0.540**

Mediation analysis (H7-H14)

According to Table 5, it shows direct and indirect effect with the 95% confidence interval for mediation analysis. Table 5 shows that the usage of the IoT device mediates the relationship between perceived usefulness and loyalty intention (indirect effect = 0.2007, 95% CI =[.1251, .2745]). Therefore, H7 is supported. The usage of IoT devices mediates the relationship between perceived usefulness and participation intention (indirect effect = 0.5051, 95% CI =[.0939, .2683]). Therefore, T8 is supported. Additionally, the usage of the IoT device mediates the relationship between perceived ease of use and intention of loyalty (indirect effect = 0.3143, 95% CI =[.2331, .4077]). Therefore, H9 is supported. The usage of the IoT device mediates the relationship between perceived ease of use and participation intention (indirect effect = 0.2954, 95% CI =[.1841, .4381]). Therefore, H10 is supported. Furthermore, the usage of the IoT device mediates the relationship between

perceived satisfaction and intention of loyalty (indirect effect = 0.2127, 95% CI =[.1270, .3022]). Therefore, H11 is supported. The usage towards IoT device mediates the relationship between perceived satisfaction and participation intention (indirect effect = 0.1833, 95% CI =[.0982, .2965]). Therefore, H12 is supported. The usage towards IoT device mediates the relationship between perceived security awareness and loyalty intention (indirect effect = 0.2028, 95% CI =[.0713, .3107]). Therefore, H13 is supported. Lastly, the usage towards the IoT device mediates the relationship between perceived security awareness and participation intention (indirect effect = 0.1523, 95% CI =[.0343, .3212]). Therefore, H14 is supported.

Table 5. Direct And indirect effect with bootstrap 95% Confidence Interval For Mediation Analysis

Predictor	Mediator	Dependent Variable	Direct Effect	Indirect Effect (95% CI)
Perceived Usefulness	Usage towards IoT Devices	Loyalty Intention	0.5344	0.2007(.1251, .2745)
Perceived Usefulness		Participate Intention	0.5051	0.1717(.0939, .2683)
Perceived Ease of Use		Loyalty Intention	0.2060	0.3143(.2331, .4077)
Perceived Ease of Use		Participate Intention	0.0954	0.2954(.1841, .4381)
Perceived Satisfaction		Loyalty Intention	0.4859	0.2127(.1270,.3022)
Perceived Satisfaction		Participate Intention	0.4432	0.1833(.0982,.2965)
Perceived Security Awareness		Loyalty Intention	0.5744	0.2028(.0713,.3107)
Perceived Security Awareness		Participate Intention	0.6297	0.1523(.0343,.3212)

Notes: Results based on 5000 bootstrap samples. CI: 95% confidence interval for bias for indirect effects.

4.0 DISCUSSION

Consistent with the result provided in Table 4, it was emphasized that there is a positive correlation between perceived usefulness and usage of IoT devices. Perceived usefulness often comes from the enhanced functionality that IoT devices offer. These devices can automate tasks, provide real-time data, and offer convenience, all of which contribute to their perceived usefulness. When users experience these benefits, they are inclined to continue using the devices (Alqarni et al., 2024). Meanwhile, perceived ease of use shows a positive correlation with the usage of IoT devices. IoT devices that are easy to set up and use effectively tend to be perceived as more useful. When users can quickly understand how to use a device and integrate it into their daily lives without significant hassle, they are more likely to perceive it as useful and continue using it. This study supports the research of Basuki et al. that states that perceived ease of use affects the use of IoT devices (Basuki et al., 2022). Next, perceived satisfaction indicates the positive correlation between the usage of IoT devices. When users perceive IoT devices as satisfying, it often means that the devices meet or exceed their expectations in terms of performance, functionality, and reliability. This fulfilment of expectations fosters a positive user experience, leading to increased use of the devices (Rock, 2024). In addition to that, the result indicates a positive correlation between perceived security awareness and the usage of IoT devices. Security-aware users are often more concerned about protecting their personal data and privacy. They are more willing to pay for IoT devices that offer the most protection for each security or privacy IoT device. Perceived security measures reassure users about the safety of their information, leading to increased use of the devices (Emami-Naeini, 2023). Furthermore, continuous usage of IoT devices often reinforces users' perception of their value. As users experience the benefits and efficiency provided by the devices over time, they develop a stronger attachment and loyalty to the brand or platform. Consistent with expectations, the usage of IoT devices significantly influences loyalty intention (Jo, 2023). In addition to that, as users interact with IoT devices to control their environment, monitor data, or automate tasks, they become more accustomed to participating in IoT devices (Madias, 2023).

Based on Table 5, H7 suggests that the usage towards IoT devices mediates the relationship between perceived usefulness and loyalty intention. According to (Le, 2021), the study highlights the crucial role of perceived usefulness in encouraging user loyalty to Fintech services. The positive experience of using Fintech during the lockdown period enhances users' intention to continue using these services, emphasizing the importance of understanding how users perceive the utility and benefits of Fintech in influencing their loyalty intention. Additionally, H8 indicates that the usage toward IoT devices mediates the relationship between perceived usefulness and participation intention. Similarly, H10 is supported, indicating that usage towards IoT devices mediates the relationship between perceived ease of use and participation intention. According to (Al-Qaysi et al., 2020), mediation analysis suggests that students' perceived usefulness of social media platforms affects their tendency to participate in collaborative learning activities, highlighting the role of perceived ease of use in shaping participation intentions. Furthermore, H9, which states that usage towards IoT devices mediates the relationship between perceived ease of use and intention of loyalty, finds support. This result is consistent with the study of (Ozturk et al., 2016), where the use of mobile applications acts as a mediator between perceived ease of use and loyalty intention, demonstrating how convenience affects user loyalty positively. Furthermore, H11 suggests that the mediating effect of usage toward IoT devices is significant in the relationship between perceived satisfaction and loyalty intention, partially supported by the study of (Kang and Hwang, 2022). When IoT devices provide convenience to users, it improves satisfaction and encourages loyalty to the service provider. Furthermore, H12 states that the mediating effect of usage toward IoT devices mediates the relationship between perceived satisfaction and participation intention, partially supported by the research of (Chohan and Hu , 2020). Allowing users to customize their interface and functionality of their IoT devices can improve satisfaction and increase the percentage of users with participation intention. Lastly, H13 suggests that the mediating effect of usage towards IoT devices is significant in the relationship between perceived security awareness and loyalty intention, partially supported by the study of (Nuseir et al., 2022). The awareness program contributes to creating more privacy awareness among IoT users. Similarly, H14 states that the mediating effect of usage towards IoT devices is significant in the relationship between perceived security awareness and participation intention, partially supported by the findings of (Esther et al., 2022). Privacy-conscious consumers can become aware of better privacy practices within the IoT industry.

5.0 CONCLUSIONS

In conclusion, this study explains the complex relationships between user perceptions, usage patterns, and intentions regarding IoT devices. The findings show the crucial role of perceived usefulness, ease of use, satisfaction, and security awareness in influencing user behaviour and intentions towards IoT devices. Consistent with previous research, our study shows a positive correlation between perceived usefulness and the use of IoT devices. The enhanced functionality and convenience offered by these devices contribute significantly to their perceived usefulness, thus fostering continued usage among users. Similarly, perceived ease of use shows up as a critical factor that affects the adoption and use of IoT devices. Devices that are easy to set up and integrate into daily routines are more likely to be perceived as useful, leading to increased usage over time. Furthermore, our findings highlight the importance of perceived satisfaction and security awareness in motivating user engagement with IoT devices. When users perceive these devices to fulfil their expectations and offering adequate security measures, they are more likely to use them regularly. Additionally, the continuous usage of IoT devices increases the perception of their value and strengthens their loyalty to the brand or platform. The mediation analyses conducted in this study further elucidate the underlying mechanisms through which user perceptions influence their intentions regarding IoT devices. Specifically, the mediating effect of usage toward IoT devices is significant in the relationships between perceived usefulness, ease of use, satisfaction, security awareness, and both loyalty and participation intentions.

6.0 Limitation

Although this study provides valuable information on the effectiveness of user perceptions and behaviours with respect to IoT devices, it is essential to acknowledge certain limitations. First, research primarily relies on self-reported data, which may introduce response biases or inaccuracies. Future studies could integrate objective measures, such as device usage data or observational methods, to complement self-reported data and improve the reliability of findings. Second, the study focuses on a specific demographic or user group, potentially limiting the process of the results to broader populations. Conducting similar research in diverse demographics and cultural contexts could provide a more comprehensive understanding of user perceptions and behaviours towards IoT devices. Furthermore, this study especially examines the relationships between individual factors such as perceived usefulness, ease of use, satisfaction, and awareness of security. Future research could explore additional variables that can affect user behaviours, such as social influences, trust in technology, or environmental factors. Additionally, while mediation analyses offer insights into the mechanisms through which user perceptions impact intentions regarding IoT devices, further research could investigate the moderating variables that may influence these relationships. For example, the role of user experience design or contextual factors in shaping perceptions and behaviours toward IoT devices warrants exploration.

7.0 Future Work

Addressing the limitations highlighted in this study offers a promising path for future research. First, to reduce the reliance on self-reported data and improve the reliability of findings, future studies could integrate objective measures such as device usage data or observational methods. This approach would provide a more comprehensive understanding of user behaviours and perceptions towards IoT devices, complementing self-reported data with experimental evidence. Secondly, to expand the process of results beyond specific demographics or user groups, researchers could conduct similar studies in diverse cultural contexts and demographic profiles. Exploring how different socio-cultural backgrounds influence user perceptions and behaviours toward IoT devices would enrich our understanding of this phenomenon and inform more comprehensive design and marketing strategies. Furthermore, future research could expand beyond the scope of the individual factors examined in this study, such as perceived usefulness, ease of use, satisfaction, and awareness of security. Exploring additional variables such as social influences, trust in technology, or environmental factors could provide a more nuanced understanding of the complex interaction between user attitudes and behaviours towards IoT devices. By considering a broader range of factors, researchers can develop more comprehensive models to predict and explain user behaviours in diverse contexts. Furthermore, while mediation analyses have provided valuable insights into the mechanisms of basic user perceptions and intentions regarding IoT devices, further research could seek moderating variables that can influence these relationships. For example, investigating the role of user experience design or contextual factors in shaping user perceptions and behaviours could offer deeper insight into how to optimize the design and deployment of IoT devices. By exploring these moderating variables, researchers can identify strategies to improve user experiences and maximize the adoption and usage of IoT devices in different user segments and contexts of users.

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9.0 APPENDIX

APPENDIX A: Questionnaire Details

Section	Questionnaire item	Options	
Demographic	Age	-	
	Gender	Male, Female, Trans and/or gender non-confirming	
Perceived Usefulness: It's about how much someone thinks a new technology will help them do tasks better			
Do you find that using IoT devices helps you perform better in personal and work-related tasks? Do you find that using IoT devices enhances the effectiveness in your personal and work-related tasks? Do you find that IoT will be useful in your personal and work-related tasks?		Almost Never 1 2 3 4 5 Almost Always	Lu, 2021
Perceived Ease of Use: It's how easy people think something new is to learn and use.			
Do you think the IoT devices are clear and easy to understand? Do you think that it is easy to get the IoT devices to do what you want it to do? Do you think that the procedures of IoT are simple to you? Do you think that you can quickly become proficient in using IoT? Do you think becoming skillful at using IoT devices is easy?		Almost Never 1 2 3 4 5 Almost Always	Lu, 2021
Perceived Satisfaction: That is not to suggest that satisfaction is the only trigger for any form of positive word of mouth communication, but some positive evaluative state would seem to be a prerequisite.			
IoT provides the information and services that I need. Using IoT services is very useful to my life in general. Utilizing the IoT is helpful in enhancing the effectiveness of my life in general. It is really fun and exciting to have IoT devices. I think this technology makes my life more interesting.		Almost Never 1 2 3 4 5 Almost Always	Shin, 2017 .
Perceived Security Awareness: Security awareness means knowing how to keep information safe and being careful online.			
I ensure my IoT device's firmware is up-to-date I scan IoT device's accessories or attachments for malware. I download IoT device applications or software from reputable sources. I ensure my IoT devices is protected by cybersecurity measures I establish a trusted relationship with IoT device manufacturers or service providers online. I will click on links provided in IoT device-related emails or messages.		Almost Never 1 2	Zhang et al., 2019 Sales et al., 2024 Muniandy et al., 2017

I verify the authenticity of requests from IoT device authorities or supports. I identify the URL I trust as the legitimate website for my IoT device's manufacturer or service provider. I feel intimidated by inquiries or requests related to my IoT device from unauthoritative sources. I create a strong password for my IoT device's I ensure the password for my IoT device is not based on personal information. I regularly change the password for my IoT device's. I refrain from sharing passwords for my IoT devices with others. I refrain from sharing passwords for my IoT devices with others.	3 4 5 Almost Always	
Usage towards Iot Devices: How users can maximize the value of IoT devices.		
I use IoT devices for home automation. (e.g., smart thermostats, smart lighting) I use IoT devices for personal health monitoring. (e.g., fitness trackers, smart scales) I use IoT devices for home security. (e.g., smart cameras, smart locks) I use IoT devices for entertainment purposes. (e.g., smart TVs, streaming devices) I use IoT devices for environmental monitoring. (e.g., air quality sensors, water quality sensors) I use IoT devices for transportation. (e.g., GPS trackers, smart car systems) I use IoT devices for tracking personal belongings. (e.g., smart tags, GPS trackers) I use IoT devices for pet care. (e.g., smart feeders, activity trackers)	Almost Never 1 2 3 4 5 Almost Always	Lynn et al., 2020 Ting et al., 2023
Loyalty Intention: Are users express a strong intention to buy again, recommend, and stay loyal to IoT devices?		
I will purchase another product offered by IoT devices online in the future. I will encourage/recommend friends and relatives to use the product offered by IoT devices. I intend to stay with IoT devices as one of my shopping channels. I intend to recommend IoT devices to others.	Almost Never 1 2 3 4 5 Almost Always	Ajayi et al., 2023
Participate Intention: Participation intention means actively joining in online discussions. It's like being at a fun online party where you enjoy reacting to and sharing posts from your favorite IoT device shops.		
When I see a post from an IoT device online shop that I like, I will "share" it. It is worth sharing posts from IoT device online shops. I'm willing to provide my experience and suggestions when my friend wants to buy from an IoT device online shop. I'm willing to recommend which products are worth buying from an IoT device online shop to my friends.	Almost Never 1 2 3 4 5 Almost Always	Emami-Naeini et al., 2019 Wibowo et al., 2021