The Importance of Internet of Things (IoT) Applications in Advancing Teaching and Learning in Property Management Practices

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Abstract: *The integration of the Internet of Things (IoT) into property management is reshaping professional practices and transforming how future practitioners are taught and trained. This study examines the importance of IoT applications in advancing teaching and learning within property management education. The research objectives are to identify key IoT attributes, evaluate their relevance to property management pedagogy, and analyse how these attributes can be embedded into teaching strategies and learning outcomes. A mixed-methods approach was employed, involving a literature review, semi-structured interviews with three industry professionals, and an online survey of 306 respondents. The findings highlight that IoT attributes such as reducing carbon emissions, improving work productivity, enhancing tenant–management relationships, strengthening safety and security, and ensuring effective indoor air quality management are not only significant in professional practice but also serve as valuable content for teaching and curriculum design. Furthermore, attributes such as space utilisation analytics, cloud-*

based maintenance, real-time communication, and technological innovation showed medium to strong correlations with property management practices (r = 0.482), underscoring their pedagogical relevance. These findings suggest that integrating IoT concepts into property management teaching enhances students' digital literacy, practical understanding, and readiness for industry transformation. Overall, the study helps bridge the gap between industry innovation and higher education by demonstrating how IoT can be leveraged to enrich teaching and learning in property management.

Keywords: *Internet of Things (IoT), Teaching and Learning, Property Management Practices*

1. INTRODUCTION

In recent years, the Internet of Things (IoT) has emerged as a transformative trend within the real estate and property management sector. IoT technologies enable innovative solutions to longstanding challenges, including data reporting frameworks, predictive maintenance, risk management, cost optimisation, and energy efficiency (Li & Yu, 2022; Zhang et al., 2021). By integrating interconnected devices and smart sensors, IoT enables real-time monitoring, automation, and analytics that enhance operational efficiency and sustainability in building management (Gubbi et al., 2013). Consequently, the adoption of IoT applications provides new opportunities for both building occupants and management personnel to improve productivity, comfort, and safety (Kumar & Mallick, 2018).

Beyond its operational advantages, the integration of IoT technologies has become increasingly significant in advancing teaching and learning practices in property management education. Embedding IoT applications into academic curricula and professional training programmes allows learners to engage with real-time data, simulate smart building systems, and develop competencies relevant to the evolving digital property landscape (Al-Fuqaha et al., 2015; Singh et al., 2020). This pedagogical shift supports experiential learning and strengthens the link between theoretical knowledge and industry practice, preparing future property managers to make informed, data-driven decisions in technologically advanced environments (Lim & Nordin, 2023).

Nevertheless, the level of awareness and adoption of IoT applications in property management remains limited. Many stakeholders remain sceptical or uncertain about the importance and relevance, the implementation costs, and the long-term benefits of IoT integration (Tan & Lee, 2021). Such perceptions may hinder the digital transformation of the property management industry and impede the evolution of innovative teaching and learning strategies within the field. Therefore, it is imperative to enhance awareness, training, and research concerning the applications and pedagogical potential of IoT to foster a more adaptive, technology-driven approach to property management practice and education (Chong et al., 2022).

2. RESEARCH BACKGROUND

The Internet of Things (IoT) paradigm has been increasingly applied across sectors, including manufacturing, logistics, healthcare, and urban infrastructure. By enabling the interconnection of devices and systems, IoT extends the potential of smart technologies to remotely monitor, analyse, and optimise complex operations, including those in Intelligent Transportation Systems (ITS), smart industries, and smart cities (Chen, 2021). In property management, IoT represents a significant innovation in how buildings and assets are managed, maintained, and monitored.

Property management can be broadly defined as the professional administration of residential, commercial, or industrial assets on behalf of property owners, to preserve and enhance asset value while ensuring operational efficiency and tenant satisfaction (Anderson & Courage, 2021). Traditionally, the scope of property management has focused on essential operational activities such as security, cleaning, and maintenance (Yiu & Yau, 2006). These functions, whether managed in-house or outsourced to third-party service providers (Oyedele, 2013), have often relied heavily on manual supervision, paper-based reporting, and reactive problem-solving approaches.

The emergence of Information and Communication Technology (ICT), particularly IoT, has transformed these conventional practices by enabling the integration of connected devices and data-driven decision-making. Through machine-to-machine (M2M) communication and sensor-based monitoring systems, IoT facilitates real-time data collection and analysis to support

predictive maintenance, energy optimisation, risk management, and enhanced user experience (Zhang et al., 2021). This digital advancement not only improves the efficiency and transparency of property management processes but also creates new opportunities for strategic management and sustainability initiatives.

Importantly, the growing role of IoT in property management underscores the need to advance teaching and learning practices in this field. As the industry shifts toward digital transformation, property management education must evolve to equip learners with the technological literacy, analytical capabilities, and problem-solving skills required to manage smart buildings effectively (Lim & Nordin, 2023). Integrating IoT applications into academic curricula and professional training provides learners with experiential exposure to real-world technologies, fostering competency in data interpretation, system integration, and digital asset management. This approach bridges the gap between theory and practice, ensuring that graduates are well prepared to navigate and lead in an increasingly data-driven property sector.

Therefore, understanding the significance of IoT in both operational and educational contexts is crucial for the future of property management. The effective integration of IoT-based applications into teaching and learning can accelerate innovation, strengthen professional readiness, and help develop a technologically adept workforce capable of sustaining the real estate industry's competitive and sustainable growth.

3. PROBLEM STATEMENT

Previous studies have examined the emerging challenges in the property sector and the potential of Internet of Things (IoT) applications to address them (Mehta, 2021). Despite the growing recognition of IoT as a transformative technology, there remains a dearth of research exploring its actual significance in enhancing property management practices, particularly from the perspective of teaching and learning integration. While numerous studies have highlighted the operational and sustainability benefits of IoT implementation, limited scholarly attention has been paid to how these technological advancements can be incorporated into property management education to prepare future professionals for the industry's evolving digital landscape.

Among the critical challenges in the property sector are climate change mitigation, real-time energy management, and indoor air quality control—all of which IoT technologies can effectively address. Climate change mitigation has been recognised as one of the most pressing global issues, including in Malaysia, due to its impact on sustainability and urban development (Abd El-Mawla et al., 2019). The growing emphasis on environmental, social, and governance (ESG) performance has prompted the real estate industry to adopt innovative, technology-driven strategies to reduce carbon emissions (Malmodin & Bergmark, 2015). Since inefficient energy consumption is a major contributor to carbon emissions and rising operational costs, IoT-enabled systems offer solutions for monitoring, optimising, and automating energy use in real time (Carletti et al., 2017). Real-time energy use and management remain uncertain or poorly implemented in many traditional property management operations, often resulting in budget inefficiencies and reduced building performance (Malmodin & Bergmark, 2015).

Additionally, indoor air quality management poses a persistent challenge in building operations, as appliances and materials within facilities may release harmful chemicals that circulate through air systems (Warren, 2011). IoT-supported technologies allow for continuous air quality monitoring through sensor networks that transmit data to facility managers and health personnel via wireless communication systems (Wolf & Serpanos, 2018). These applications highlight the capacity of IoT not only to optimise building performance but also to ensure healthier and more sustainable living and working environments.

However, while the practical applications of IoT in addressing property management challenges are well documented, translating these innovations into teaching and learning practices remains limited. Future property managers must possess not only managerial and technical knowledge but also digital competencies to analyse, interpret, and apply IoT-generated data to improve building operations and sustainability outcomes. Without embedding IoT literacy and practical exposure into educational curricula, there is a risk of producing ill-equipped graduates to manage smart properties or lead digital transformation initiatives in the real estate sector (Lim & Nordin, 2023).

Thus, this study seeks to address the gap by examining the role of IoT applications in advancing teaching and learning in property management. It aims to highlight how IoT can serve as both an operational tool and an

educational platform that bridges theoretical understanding with real-world application to enhance sustainability, efficiency, and professional readiness in the property management discipline.

4. AIM AND OBJECTIVES OF THE RESEARCH

This research aims to determine the importance of Internet of Things (IoT) applications in advancing teaching and learning in property management practices in Malaysia. The specific objectives are as follows.

To identify the importance of Internet of Things (IoT) applications in advancing teaching and learning in property management practices in Malaysia.
To determine the importance of attributes of Internet of Things (IoT) applications in advancing teaching and learning in property management practices in Malaysia.

To analyse the correlation between the attributes of Internet of Things (IoT) applications in advancing teaching and learning with different aspects of property management practices in Malaysia.

5. LITERATURE REVIEW

Several key aspects of the importance of IoT applications in advancing teaching and learning in property management are reviewed as follows.

5.1 PROPERTY MANAGEMENT

Property management is the process of managing and maintaining third-party-owned properties, with the property manager's role being to ensure the property retains its value and generates income for the benefit of the owner and users. This involves two main categories of maintenance: planned and unplanned, which are conducted based on the specific needs, functions, and designs of different property types (Kaur & Solomon, 2021).

From a teaching and learning perspective, understanding these management categories forms the foundation of property management education. Integrating IoT technologies in the curriculum enables students to visualise and simulate maintenance operations through real-time data monitoring and digital platforms. Such experiential learning using IoT-based tools prepares students to manage diverse property assets more effectively, reflecting real industry practices.

5.2 ATTRIBUTES OF INTERNET OF THINGS (IOT) APPLICATIONS IN PROPERTY MANAGEMENT PRACTICES

IoT applications in property management encompass various attributes that have significant implications for both professional practice and academic training. These include space utilisation and data analytics (Korzun et al., 2015), cloud-based maintenance systems (Lee et al., 2016), energy control and management (Omar et al., 2015), technological innovation in the real estate sector (Zhen, 2012), and real-time communication (Dusadeerungsikul & Nof, 2021).

Embedding these attributes into teaching and learning modules fosters data-driven decision-making skills, technological literacy, and innovative problem-solving, which are essential for future property managers.

5.2.1 SPACE UTILISATION AND DATA ANALYTICS

Space utilisation refers to the automated process of identifying and optimising the use of facilities by relocating operations or assets based on available space (Pierce & Knecht, 2009). IoT systems and analytics allow property managers to collect and analyse data on occupancy, usage, and energy patterns in real time (Bolla et al., 2011).

In academic contexts, these IoT applications enhance teaching by enabling students to analyse live or simulated building data and practice decision-making related to space management. Through such experiential learning, students develop critical thinking and analytical skills, bridging the gap between theoretical knowledge and industry-based applications.

5.2.2 CLOUD-BASED FOR PROPERTY MAINTENANCE

Cloud-based systems enable property managers to access property management software remotely without physical servers (Cloud Secure Tech, 2021). These platforms, such as AppFolio, integrate maintenance, accounting, and advertising management into a single interface. Future developments may involve integrating Geographic Information Systems (GIS), Virtual Reality (VR), and network technologies to enhance service quality (Christudason, 2008).

For teaching and learning, cloud-based applications provide interactive digital environments for students to simulate maintenance workflows, manage property databases, and collaborate on projects remotely. This technology-driven approach cultivates digital competency, teamwork, and adaptability skills increasingly demanded in the modern property management industry.

5.2.3 ENERGY CONTROL AND MANAGEMENT

Buildings rely heavily on electricity, and improving energy efficiency has become a global priority (Mariano-Hernández et al., 2021; Al-Rakhami et al., 2019). Building Energy Management Systems (BEMS) integrate sensors and analytics to improve energy performance (Bonilla et al., 2018).

In educational contexts, incorporating IoT-based BEMS into property management training allows students to observe real-time energy data, analyse consumption trends, and propose efficiency strategies. Such integration promotes sustainable thinking and environmental responsibility among learners, aligning academic outcomes with green property management practices.

5.2.4 TECHNOLOGICAL INNOVATION IN THE REAL ESTATE SECTOR

Technological innovation is interdependent and continuously evolving through interaction with other technologies (Coccia, 2018; Ulamen & Bergek, 2021). In the real estate sector, PropTech integrates IoT, Artificial Intelligence, Blockchain, Machine Learning, 5G, and data analytics (Srivastava, 2021).

Embedding PropTech innovations in teaching supports technology-enhanced learning, where students explore cutting-edge tools to manage assets, analyse markets, and simulate decision-making. This approach fosters innovation, creativity, and digital fluency, ensuring graduates are ready for the dynamic demands of smart property management environments.

5.2.5 REAL-TIME COMMUNICATION

Real-time communication underpins IoT functionality by ensuring timely, accurate, and efficient system responses (Underwood, 2018; Dietrich, 2010). In property management, it enables real-time monitoring, predictive maintenance, and rapid reporting (Carli et al., 2017).

For teaching and learning, real-time communication systems allow students to interact with live dashboards, monitor maintenance alerts, and participate in real-time decision simulations. These immersive educational experiences cultivate situational awareness, technical proficiency, and immediate problem-solving skills as key capabilities for managing smart buildings and IoT-integrated properties.

6. THE IMPORTANCE OF INTERNET OF THINGS (IOT) APPLICATIONS IN ADVANCING TEACHING AND LEARNING IN PROPERTY MANAGEMENT PRACTICES

This study offers a comprehensive explanation of the importance of Internet of Things (IoT) applications in property management and their potential to advance teaching and learning in the discipline. A comprehensive review of prior research indicates that IoT technologies are increasingly recognised for their ability to reduce carbon emissions, enhance tenant-management relationships, improve indoor air quality (IAQ), and strengthen safety and security systems in buildings. These applications not only contribute to efficient and sustainable property management but also represent critical areas for developing the knowledge and skills of future property managers.

From an educational standpoint, integrating IoT into teaching and learning transforms traditional property management education into a more experiential, data-driven, and problem-based learning environment. For instance, IoT systems that monitor energy consumption or carbon output can be used in classroom simulations and digital labs to help students analyse real-time sustainability data and design energy-efficient strategies. Such activities strengthen students' understanding of environmental stewardship and sustainable property operations.

Moreover, IoT-enabled tenant-management systems, such as smart feedback portals and real-time communication platforms, can be incorporated into learning modules to train students in customer relationship management and service responsiveness, mirroring real-world professional interactions. Similarly, IoT-based IAQ monitoring tools and smart safety devices give students opportunities to explore health, comfort, and safety parameters in the built environment, reinforcing the importance of occupant well-being in property management education.

By embedding these IoT applications into teaching and learning practices, educators can bridge the gap between theory and real-world practice, fostering a new generation of property management graduates who are technologically proficient, sustainability-minded, and capable of making data-informed decisions. Therefore, the importance of IoT applications extends beyond operational efficiency; it plays a transformative role in enhancing curriculum design, practical training, and digital literacy within property management education.

6.1 REDUCE CARBON EMISSION

Climate monitoring has become one of the most pressing global concerns, with climate change affecting safety, food security, and energy systems worldwide. Information and Communication Technology (ICT), such as satellite sensing, ocean sensors, and weather radars, has become a major tool for understanding environmental impacts (Saeed et al., 2019). In the property sector, heightened awareness of carbon emissions and environmental, social, and governance (ESG) standards has driven the adoption of innovative, IoT-enabled solutions. Research indicates that property managers can reduce energy consumption by up to 25% through smart IoT systems that monitor and optimise building energy use (Ngu et al., 2016).

From a teaching and learning perspective, IoT-based carbon reduction systems can be integrated into property management curricula to enhance students' understanding of sustainable building operations and green management strategies. By analysing real-time energy data and simulating IoT-controlled systems, students can learn how digital technologies support carbon-neutral building performance and align with national sustainability goals. Such learning experiences promote environmental literacy, critical thinking, and data interpretation skills, which are essential for future property managers operating in sustainable real estate environments.

6.2 ENHANCE TENANT-MANAGEMENT RELATIONSHIPS

Improving tenant satisfaction and engagement is central to successful property management. IoT-enabled systems such as automated smart lighting, climate control, and digital feedback applications enhance communication and service quality, leading to higher tenant loyalty (Traboulsi & Knaught, 2021). For instance, automated lighting systems improve comfort, safety, and energy efficiency, while data-driven management tools allow property managers to respond quickly to tenant needs (Tupakula & Varadharajan, 2014).

In an educational context, these IoT applications can be used to teach students about digital tenant engagement and customer relationship management. By simulating IoT-based service systems, learners gain exposure to real-world management scenarios and develop interpersonal, analytical, and decision-making skills. Integrating these systems into teaching also enables students to evaluate how digital solutions affect client satisfaction and operational efficiency, making these outcomes key learning outcomes in modern property management education.

6.3 ENHANCED INDOOR AIR QUALITY (IAQ) MANAGEMENT

Many building systems produce harmful emissions that can degrade indoor air quality (IAQ) and affect occupant health. The COVID-19 pandemic underscored the importance of effective Air Quality Management (AQM) systems in maintaining safe indoor environments (Carletti et al., 2017). IoT sensors now monitor critical parameters such as CO_2 concentration,

temperature, humidity, light, sound and relay data to centralised platforms for real-time analysis (Kalaithasan et al., 2018). This enables early detection of "Sick Building Syndrome" and supports proactive maintenance strategies.

For teaching and learning, IoT-based IAQ management provides hands-on learning experiences that enhance students' understanding of health, comfort, and environmental quality in building management. Educators can incorporate real-time IAQ data into coursework, allowing students to interpret environmental readings, diagnose building health issues, and propose management interventions. These activities cultivate analytical skills and sustainability awareness, preparing students to manage smart, health-conscious buildings in their future careers.

6.4 SAFETY AND SECURITY

Safety and security are critical concerns for property owners, managers, and occupants. IoT systems enhance these aspects through networked access control, surveillance cameras, motion sensors, and environmental monitoring systems, ensuring protection and operational reliability (Wolf & Serpanos, 2018). Unlike traditional systems that function in isolation, IoT-enabled security networks are interoperable and data-driven, allowing property managers to monitor and analyse multiple building functions in real time.

In teaching and learning, IoT-based safety systems can be used to train students in risk management, emergency response, and smart security system design. By engaging with simulated or real IoT security data, students learn how digital technologies contribute to proactive facility management and situational decision-making. This experiential approach reinforces practical skills, technical literacy, and critical awareness of cybersecurity in property management.

Documentation, and preparation for accreditation compliance (Marnnoi, 2024). Preparatory work, such as developing comprehensive course materials, recorded lectures, interactive assessments, detailed instructional guides, and extensive documentation portfolios required by program accreditation bodies, is mostly done by coordinators and subject-matter experts, usually lecturers

and instructional designers (Rensburger et al., 2021). The program can only be run after getting accredited. After implementation, ongoing tasks include monitoring student engagement, managing virtual laboratories, continuously updating content to keep pace with rapidly evolving technologies, maintaining academic integrity in remote assessments, and preparing periodic accreditation reports. Additionally, faculty must maintain detailed records of student performance data, course delivery modifications, and continuous improvement initiatives to satisfy accreditation review cycles (MQA, 2021).

	Wilander (2018)	Malmodin & Bergmark (2015)	Mehta (2021)	Nguetal. (2016)	Bounyaetal. (2017)	O'Brien (2014)	Traboulsi & Knaugh (2021)	Tupakula & Varadharajan (2014)	Carletietal. (2017)	Kalaithasanetal. (2018)	Wolf & Serpanos (2018)
Importance of Internet of Things (IoT) Applications in Advancing Teaching and Learning in Property Management Practices											
1. Reduce Carbon Emissions											
● Climate-related disasters cause millions of deaths	√										
● Tackling inefficient energy use			√								
● Investigating key climate-changing variables		√									
● IoT-enabled energy savings technologies help save costs				√							
2. Increase Work Productivity											
● Can be classified into absenteeism and presenteeism					√						
● The mean time to recover is much faster compared to the manual working style						√					
3. Enhance Tenant-Management Relationship											
● Having appropriate management tools								√			
● Lowering operational cost in benefitting building occupants							√				
● Comprehensive information is being shared							√				
4. Enhanced Indoor Air Quality (IAQ) Management											
● Long-period indoor needs better ventilation									√		
● Sensors detecting "Sick Building Syndrome" based on parameters									√	√	
5. Safety and Security											
● Keeps the building functionality at a higher operational level											√
● Increases the possibilities of new technological innovations used											√

Source: Researcher (2025)

Table 1: Importance of Internet of Things (IoT) Applications in Advancing Teaching and Learning in Property Management Practices on Previous Research

Table 1 highlights the importance of Internet of Things (IoT) application attributes in advancing teaching and learning in property management. Five (5) important attributes have been further reviewed from the past literature.

7. METHODOLOGY

Data were collected through a combination of semi-structured interviews and online surveys, ensuring data triangulation for greater reliability and validity.

7.1 SEMI-STRUCTURED INTERVIEWS

Preliminary interviews are conducted to obtain expert opinions and contextual understanding of IoT adoption in real property management settings. Interview questions are designed to explore how IoT practices, such as smart maintenance, energy management, and digital communication, can be used as learning tools or case studies in property management education.

Prior preparation, including question formulation and interview scheduling, ensures that the data collected provides meaningful insights into how industry practices can inform and enhance teaching methods. These respondents are selected for their direct involvement in IoT-based building management systems, making them valuable sources for identifying real-world applications that support curriculum relevance and teaching innovation in property management programs (see Table 3).

Respondent Code	Position	Company Location
E1	Property Manager	Axiata Arena, Bukit Jalil
E2	Engineer	Top Glove, Setia Alam
E3	Property Executive	Savills, Damansara

Table 3. Respondents of the Case Study

7.2 ONLINE SURVEY QUESTIONNAIRE

Following the interviews, an online survey questionnaire will be distributed to a broader sample of property managers, engineers, and executives. The questionnaire aims to measure perceptions, awareness, and attitudes toward the use of IoT and its relevance to professional learning, upskilling, and educational integration in the field.

Two types of surveys are used: a cross-sectional survey to capture the current understanding and implementation levels of IoT in property management education and practice, and a longitudinal survey to assess the perceived evolution of IoT skills and their long-term impact on learning outcomes. The survey collects both quantitative and qualitative responses to examine how IoT enhances teaching practices, such as digital simulations, real-time data learning, and smart campus initiatives.

7.3 SAMPLING TECHNIQUE AND RESPONDENT PROFILE

This study uses purposive sampling, specifically homogeneous purposive sampling, to ensure participants share characteristics relevant to the study—namely, professionals and users of mixed-use, commercial, and industrial buildings who are exposed to IoT applications in their work.

A total of 382 respondents were targeted, representing diverse roles within the property management and engineering sectors. Out of these, 306 valid responses were collected, representing an 80% response rate. This high participation rate ensures the data collected is representative and reliable for analysis. Including industry practitioners who actively engage with IoT technologies provides critical insights into how industry experiences can be transformed into teaching content and learning simulations in academic programs.

7.4 DATA ANALYSIS

The data from the surveys and interviews were analysed using a mixed-method interpretive approach. Qualitative data from interviews has been analysed thematically to identify patterns in respondents' experiences with IoT systems and their educational implications. Quantitative data from surveys processed using descriptive and inferential statistical methods to determine the level of awareness, perceived benefits, and readiness for IoT integration in property management learning.

Through this analysis, the study aims to link IoT implementation outcomes such as energy efficiency, tenant engagement, and safety enhancement with their pedagogical applications, such as simulation-based learning, case-based instruction, and digital skill development.

In summary, the chosen research methodology combines qualitative and quantitative techniques to explore both the operational importance of IoT in property management and its educational potential in advancing teaching and learning. By aligning academic inquiry with real-world practices, this study not only identifies the current impact of IoT but also proposes how these technologies can shape the future curriculum design, experiential learning, and professional competencies of property management students.

8. FINDINGS AND DISCUSSION

This section presents and discusses the study's findings on the importance of IoT applications in advancing teaching and learning in property management. The results are derived from interviews and survey analyses, emphasising how IoT-related innovations not only transform operational property management but also serve as catalysts for educational development, digital skill enhancement, and experiential learning in property management education.

8.1 ATTRIBUTES OF IOT APPLICATIONS IN PROPERTY MANAGEMENT PRACTICES IN MALAYSIA

The findings reveal three key attributes of IoT applications that are increasingly integrated into Malaysian property management practices: space utilisation and data analytics, cloud-based property maintenance, and energy control and management. These attributes are crucial not only for improving operational performance but also for shaping teaching and learning curricula that reflect real-world digital transformation.

(a) Space Utilisation and Data Analytics
Respondents emphasised inefficiencies in traditional space management, describing them as time-consuming, non-computable, and non-flexible. Manual tasks, such as on-site assessment, consumed excessive time and resources. IoT-based solutions, through real-time data analytics, automate these repetitive tasks and enable systematic data collection (e.g., occupancy rates, space optimisation).

For teaching and learning, this highlights the need to integrate IoT-driven spatial analytics software into property management education. Students can learn how to interpret real-time data for decision-making, fostering analytical and problem-solving skills critical in managing smart buildings. By simulating real IoT dashboards or digital twins in classrooms, students can gain practical, data-driven experience in property management.

(b) Cloud-Based Property Maintenance
Respondents further identified cloud-based systems, particularly for HVAC and lighting, as transformative in streamlining operations. IoT-enabled platforms centralise data, enhancing coordination and reducing Mean Time to Recover (MTTR).

For educators, this finding provides strong justification to incorporate cloud-based facility management modules into coursework. Students should be exposed to remote monitoring tools, mobile maintenance dashboards, and centralised digital record systems, enhancing their digital literacy and readiness for IoT-integrated property environments. This not only bridges academic learning with professional practice but also promotes adaptive learning using real-world technologies.

(c) Energy Control and Management

The study also found that Building Energy Management Systems (BEMS) enable real-time optimisation of energy usage, promoting sustainability and efficiency. Respondents associated these systems with reduced operational costs and improved environmental performance.

From a pedagogical perspective, BEMS represents an essential case study for sustainability education. Incorporating BEMS simulations into property management courses would allow students to explore carbon footprint monitoring, real-time energy tracking, and green-building certifications, aligning classroom learning with Malaysia's sustainability agenda and SDG 11 (Sustainable Cities and Communities).

8.2 AWARENESS AND COMPREHENSION OF IOT AND PROPERTY MANAGEMENT PRACTICES

Table 4 shows that the majority of respondents demonstrated strong awareness and understanding of both IoT and Property Management Practices (PMP), with 62.4% extremely aware of IoT and 64.4% extremely aware of PMP. Over 50% of respondents rated their comprehension as excellent.

Variable	Scale	Frequency	Percentage
Are you familiar with the term Internet of Things (IoT)?	Not Aware	24	7.8
	Slightly Aware	21	6.9
	Moderately Aware	70	22.9
	Extremely Aware	191	62.4
Are you familiar with the term Property Management Practices (PMP)?	Not Aware	14	4.6
	Slightly Aware	26	8.5
	Moderately Aware	69	22.5
	Extremely Aware	197	64.4
How would you rate your comprehension of the term Internet of Things (IoT)?	Weak	18	5.9
	Moderate	42	13.7
	Good	88	28.8
	Excellent	158	51.6
How would you rate your comprehension of the term Property Management Practices (PMP)?	Weak	16	5.2
	Moderate	38	12.4
	Good	87	28.4
	Excellent	165	53.9

Source: Researcher (2025)

Table 4. Awareness and Comprehension Based on Frequency

This finding underscores the growing familiarity of industry practitioners with digital tools and smart technologies. In the context of teaching and learning, such awareness signals a readiness among property professionals to participate in IoT-integrated education and training programs. Universities and training institutions can leverage this readiness to introduce IoT-based learning modules, augmented reality simulations, and digital competency workshops, ensuring that students and practitioners develop relevant skills for Industry 4.0.

8.3 THE IMPORTANCE OF IOT ATTRIBUTES IN ADVANCING TEACHING AND LEARNING IN PROPERTY MANAGEMENT

Semi-structured interviews identified several key attributes of IoT that contribute to both property management efficiency and educational enhancement. These include carbon emission reduction, increased work productivity, improved tenant-management relationships, enhanced indoor air quality, and strengthened safety and security (refer to Table 5).

Attributes	Results
Reduce carbon emission	• IoT-enabled smart devices reduce energy use by up to 25%, supporting carbon-neutral developments and green education frameworks.
Increase work productivity	• IoT facilitates Machine-to-Machine (M2M) communication, reducing response times and automating workflows — relevant for teaching digital facility management.
Enhancement of the tenant-management relationship	• Apps like VYROX (AUTOSERVA) strengthen communication; integrating such case studies in teaching develops student understanding of digital customer engagement.
Improvement of Indoor Air Quality (IAQ)	• IoT-based IAQ management promotes occupant health; educators can use these systems for experiential learning in sustainable building design.
Safety and security	• IoT interoperability (e.g., sensors, access control) provides rich datasets for student analysis in smart property management labs.

Source: Researcher (2025)

Table 5. Response of the Respondents based on Attributes of Internet of Things (IoT) Applications in Property Management Practices in Malaysia

From an educational standpoint, these findings demonstrate IoT's dual role as both a professional tool and a pedagogical instrument. For example, IoT-based platforms can be introduced into classroom environments to simulate energy monitoring, predictive maintenance, and security analytics, thus fostering active learning, digital literacy, and problem-solving competencies among property management students.

8.4 CORRELATION BETWEEN IOT ATTRIBUTES AND PROPERTY MANAGEMENT ASPECTS

Spearman's correlation analysis revealed positive correlations between IoT attributes and property management outcomes, validating the transformative role of IoT in optimising workflows, improving energy efficiency, and enhancing safety. Notably, Space Utilisation Analytics (Attribute 1) has shown moderate correlation (0.319–0.369) with health, well-being, and reduced carbon footprint as key themes for sustainability education. Cloud-Based Maintenance (Attribute 2) has displayed a strong correlation (0.411–0.482) with process visibility and workflow transformation, which is valuable for teaching smart operational strategies. Energy Control and Management (Attribute 3) shows a strong correlation (0.432) with network optimisation and user comfort, providing practical examples for student energy analytics projects. These findings reinforce that IoT-based property management practices can serve as real-world learning models, enabling students to engage in evidence-based learning, problem-solving, and data-driven decision-making.

Spearman's ρ	Correlation Coefficient	Correlation of IoT Attributes and Aspects of PMP	Sig. (2-tailed)	Significance of IoT Attributes and PMP
1. Space Utilisation Analytics				
• Increase Work Productivity	0.285	Weak	0.000	Significant
• Reduce Human Error	0.132	Weak	0.021	Significant
• Reduce Operational Cost	0.234	Weak	0.001	Significant
• Enhance Health and Well-Being	0.369	Moderate	0.001	Significant
• Reduce Impact on Carbon Footprint	0.319	Moderate	0.001	Significant
• Performance Rating	0.331	Moderate	0.001	Significant
2. Cloud-Based Maintenance				
• Response Time to Recover	0.277	Weak	0.001	Significant
• Increase Security	0.283	Weak	0.041	Significant
• Improve Management Workflow	0.325	Moderate	0.001	Significant
• Streamlining Property Maintenance	0.411	Strong	0.001	Significant
• Enhance the Overall Transparency	0.482	Strong	0.001	Significant
• Performance Rating	0.434	Strong	0.001	Significant
3. Energy Control and Management				
• Reduce Operational Cost	0.169	Weak	0.003	Significant
• Total Optimisation of Energy Networks	0.223	Weak	0.001	Significant
• Enhance Demand-Based Pricing Models	0.357	Moderate	0.001	Significant
• Increase Comfort of Building Occupant	0.359	Moderate	0.001	Significant
• Data Traffic Lowers the Delay and Networking	0.432	Strong	0.003	Significant
• Performance Rating	0.267	Weak	0.001	Significant
4. Technological Innovation				
• Increase Efficiency of Building Performance	0.125	Weak	0.028	Significant
• Increase Work-Efficiency	0.208	Weak	0.001	Significant
• Improve Flow of Communication	0.388	Moderate	0.000	Significant
• Increase Comfort of Building Occupant	0.351	Moderate	0.000	Significant
• Streamlining Building Operations	0.394	Moderate	0.001	Significant
• Performance Rating	0.337	Moderate	0.001	Significant
5. Real-Time Communication				
• Enhance Tenant-Management Relationship	0.125	Weak	0.028	Significant
• Increase Return on Investment (ROI)	0.208	Weak	0.001	Significant
• Increase Work Productivity of the Management Team	0.388	Moderate	0.001	Significant
• Increase Comfort of Building Occupant	0.351	Moderate	0.001	Significant
• Performance Rating	0.337	Moderate	0.001	Significant

Table 6. Spearman's Correlation between Attributes of IoT and Different Aspects of PMP

9. CONCLUSION

In conclusion, the findings confirm that IoT applications provide significant benefits for both property management and education. The integration of IoT in property management practices promotes operational excellence, sustainability, and data transparency—while simultaneously advancing teaching and learning outcomes by: Enabling practical, hands-on learning using live IoT data and

simulation tools; Strengthening digital and analytical competencies among learners; Fostering sustainability consciousness through IoT-based green building case studies; Promoting industry-academia collaboration in digital property management innovation. Thus, IoT serves as both a technological enabler and an educational catalyst, bridging the gap between classroom learning and professional application. The study underscores that advancing teaching and learning in property management requires embedding IoT-driven experiential learning, data literacy, and sustainability awareness into academic and professional training frameworks.

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12. AUTHORS' CONTRIBUTION

Siti Hasniza Rosman conceptualised the study, designed the methodology, supervised the research process, and led the project administration and funding acquisition. Siti Hasniza Rosman and Suhana Ismail conducted the investigation and collected the data. Siti Hasniza Rosman performed the formal analysis and prepared the original draft of the manuscript. Suhana Ismail, Rohayu Ab Majid, and Emma Marinie Ahmad Zawawi contributed to data interpretation and validation. Rohayu Ab Majid and Emma Marinie Ahmad Zawawi reviewed and edited the manuscript and contributed to the visualisation. All authors have read and agreed to the published version of the manuscript.

13. CONFLICT OF INTEREST DECLARATION

We certify that the article is the authors' and co-authors' original work. The article has not received prior publication and is not under consideration for publication elsewhere. This research/manuscript has not been submitted for publication, nor has it been published in whole or in part elsewhere. We attest that all authors have contributed significantly to the work, the validity and legitimacy of the data, and the interpretation of the data for submission to IJELHE.

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